Jaana-Maija Koivisto

LEARNING CLINICAL REASONING THROUGH GAME-BASED SIMULATION

Design principles for simulation games

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To Elisa, Akseli, Iida and Juha

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Abstract
The aim of this study was to obtain knowledge about learning clinical reasoning through game-based simulation. This knowledge could be used in developing and embedding new learning methods for clinical reasoning in nursing education. Research has shown that nursing students lack knowledge and skills in detecting and managing changes in patients' clinical conditions. This is often due to insufficient clinical reasoning, and thus, educational organisations need to more effectively enable the development of clinical reasoning during education. Digitalisation in higher education is increasing, and the use of virtual simulations and, recently, serious games to support professional learning and competence development is growing. The purpose of this research was to generate design principles for simulation games that enhance learning and to design and develop a simulation game for learning clinical reasoning. Furthermore, to enable development of such a simulation game that enhances learning, the purpose was to investigate nursing students learning through gaming.

A design-based research methodology was used since such a methodology encourages the development of knowledge that advances pragmatic and theoretical aims. Iterative cycles of analysis, design, development, testing and refinement were conducted via collaboration among researchers, nurse educators, students, programmers, 3D artist and interface designers in a real-world setting. Mixed research methods were used to produce new knowledge on learning clinical reasoning through game-based simulation, which refers to a learning method that combines game elements, simulations and learning objectives. This knowledge was used to generate design principles for a simulation game.

The results indicated that games used to provide significant learning experiences for nursing students need to share some of the characteristics of leisure games, especially visual authenticity, immersion, interactivity and feedback systems. In terms of the clinical reasoning process, students improved in their ability to take action and collect information but were less successful in learning to establish goals for patient care and to evaluate the effectiveness of interventions. The findings showed that usability, application of nursing knowledge and exploration are the aspects of a simulation game that have the greatest impact on learning clinical reasoning. It was also revealed that authentic patient-related experiences, feedback and reflection have an indirect effect on learning clinical reasoning. Users who had played digital games daily or occasionally before participating in the study felt that they learned clinical reasoning by playing the game more than those who did not play at all. The results of this design-based research project facilitated the generation of design principles for simulation games based on theoretical and empirical knowledge.

This study provided multiple opportunities to advance our knowledge of nursing students' learning processes and experiences of learning clinical reasoning through game-based simulation. Its results add to the growing body of literature on game development in the field of nursing education by providing design principles for educational simulation games. Increasingly, educators need to be future oriented; they need to be able to design and adopt new pedagogical innovations. This study makes a major contribution to research on nursing education by presenting a design-based research methodology to be used in designing, developing and embedding new technology-enhanced learning environments in nursing education.

Keywords: clinical reasoning, game-based simulation, learning, design principles, simulation game, design-based research, nursing education

Helsingin yliopisto, Kasvatustieteellinen tiedekunta
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Jaana-Maija Koivisto

Kliinisen päätöksenteon oppiminen pelillisen simulaation avulla
Simulaatiopelien design-periaatteet

Tiivistelmä
Tutkimuksen tavoitteena oli tuottaa tietoa kliinisen päätöksenteon oppimisesta simulaatiopeliä pelaamalla sekä oppimiseen vaikuttavista tekijöistä. Tuotettua tietoa voidaan hyödyntää kehitettäessä uusia menetelmiä kliinisen päätöksenteon opetukseen. Aikaisempien tutkimusten mukaan sairaanhoitajaopiskelijoiden kliinisen päätöksenteon osaamisessa ilmenee puutteita erityisesti potilaan kliinisen tilan huononemisen havaitsemisessa ja ennaltaehkäisyssä. Tämän vuoksi koulutusorganisaatioiden tulee entistä tehokkaammin edistää kliinisen päätöksenteon kehittymistä koulutuksen aikana. Virtuaalisimulaatioiden ja viime aikoina myös hyötypelien käyttö terveysalan koulutuksessa ammatillisen osaamisen vahvistamisessa on lisääntynyt korkeakoulutuksen digitalisaation myötä. Tämän tutkimuksen tarkoituksena oli muodostaa design-periaatteet oppimista edistävän simulaatiopelin kehittämiseen sekä suunnitella ja kehittää simulaatiopeli kliinisen päätöksenteon oppimiseen. Lisäksi tarkoituksena oli tutkia sairaanhoitajaopiskelijoiden oppimista simulaatiopelillä, jotta voidaan kehittää oppimista edistävä peli.

Tutkimuksessa toteutettiin design-tutkimuksen lähestymistapaa. Tutkimus toteutettiin iteratiivisissa sykleissä, joissa kehityskohteen analysointi, simulaatiopelin suunnittelu, kehittäminen, testaaminen ja uudelleen suunnittelu sekä reflektointi ja raportointi vuorottelivat. Tutkimus toteutettiin tutkijoiden, hoitotyön opettajien ja opiskelijoiden sekä pelinkehittäjien (ohjelmoijat, käyttöliittymäsuunnittelijat ja 3D artisti) yhteistyössä aidoissa ympäristöissä. Tutkimus oli monimenetelmätutkimus. Iteratiivisissa sykleissä syntynyttä tietoa kliinisen päätöksenteon oppimisesta simulaatiopelillä hyödynnettiin design-periaatteiden muodostamisessa tutkimusprosessin aikana.

Tulosten mukaan merkittävät oppimiskokemukset edellyttävät, että oppimiseen tarkoitetuissa simulaatiopeleissä on hyödynnettävä viihdepelien ominaisuuksia kuten autenttisuus, immersiivisyys, interaktiivisuus ja palautejärjestelmät. Parhaiten opiskelijat kokivat oppivansa pelaamalla tiedon keräämistä ja hoitotyön toteuttamista. Näitä vähemmän he kokivat oppivansa asettamaan hoitotyön tavoitteita sekä arvioimaan hoitotyötä. Tulosten mukaan oppimista simulaatiopeliä pelaamalla selittivät käytettävyys, hoitotyön tiedon käyttö sekä tutkiskelemalla oppiminen. Lisäksi oppimiseen vaikuttivat autenttiset potilaskohtaiset kokemukset, palautteen saaminen sekä reflektointi. Opiskelijat, jotka pelasivat digitaalisia pelejä päivittäin tai toisinaan, kokivat oppivansa kliinistä päätöksentekoa enemmän kuin ne, jotka eivät pelanneet lainkaan. Tutkimusprosessissa syntyneen teoreettisen ja empiirisen tiedon pohjalta muodostettiin design-periaatteet simulaatiopelin kehittämiseen. Design-periaatteet esitetään käytännöllisinä suosituksina, joita pelinkehittäjät voivat soveltaa kehittäessään simulaatiopelejä kliinisen päätöksenteon oppimiseen.

Tutkimus tuotti tietoa simulaatiopelejä pelaavien sairaanhoitajaopiskelijoiden oppimisprosesseista sekä oppimiskokemuksista. Tutkimus täydentää aikaisempaa tutkimustietoa oppimista tukevien pelien kehittämisestä terveysalalla tuottaen design-periaatteet simulaatiopelin kehittämiseen. Tätä tietoa voidaan hyödyntää kehitettäessä pelejä terveysalan koulutukseen. Tulevaisuudessa opettajilta edellytetään kykyä suunnitella ja kehittää uusia innovatiivisia oppimismenetelmiä. Tämä tutkimus kuvaa design-tutkimuksen prosessin kokonaisuudessaan ja tätä tietoa kouluttajat voivat hyödyntää omassa työssään uusien digitaalisten innovaatioiden suunnittelussa ja toteutuksessa sekä hoitotyön koulutuksessa että muualla terveysalalla mutta myös muilla ammatillisen koulutuksen alueilla.

Avainsanat: kliininen päätöksenteko, pelillinen simulaatio, oppiminen, design-periaatteet, design-tutkimus, hoitotyön koulutus

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Helsinki April 9th 2017

Jaana-Maija Koivisto

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(II) Koivisto, J-M., Multisilta, J., Niemi, H., Katajisto, J., & Eriksson, E. (2016a). Learning by playing: A cross-sectional descriptive study of nursing students' experiences of learning clinical reasoning. *Nurse Education Today*, *45*, 22–28. doi:10.1016/j.nedt.2016.06.009.

(III) Koivisto, J-M., Haavisto, E., Niemi, H., Katajisto, J., & Multisilta, J. (2016b). Elements explaining learning clinical reasoning using simulation games. *International Journal of Serious Games, 3*(4), 29-43. http://dx.doi.org/10.17083/ijsg.v1i4.47

(IV) Koivisto, J-M., Haavisto, E., Niemi, H., Haho, P., Nylund, S., & Multisilta, J. Design principles for simulation games: Designing and developing a simulation game for nursing education. Submitted.

1 Introduction

Many researchers have found deficiencies in the ability of nurses to detect signs of deterioration in hospitalised patients, and this may lead to severe adverse events including death (Ludikhuize et al., 2012; Soar et al., 2015). For example, in the UK, the overall incidence of adult in-hospital cardiac arrest was 1.6 per 1000 hospital admissions based on an analysis of the UK National Cardiac Arrest Audit database (Nolan et al., 2014). A Finnish study (Skrifvars et al., 2006) revealed that patients with documented clinically abnormal symptoms before an incidence of in-hospital cardiac arrest have a worse outcome than those without such symptoms. Kajander-Unkuri et al. (2014a) found gaps in nursing students' skills related to cardiovascular circulation. Such deficiencies, especially those in recognising internal bleeding, recognising arrhythmias, taking appropriate action in the event of an arrhythmia, and preventing and treating circulatory shock, can lead to life-threatening situations. The inadequacy is often due to poor or insufficient clinical reasoning. Soar et al. (2015) state that nursing staff lack knowledge and skills in acute care; their failure to recognise deterioration is often caused by infrequent, late, or incomplete vital sign assessments and a lack of knowledge of normal vital sign values. Nonetheless, signs of deterioration are clear and can be detected 24–48 hours before a life-threatening event (Kim et al., 2015; Ludikhuize et al., 2012; van Galen et al., 2016). Nurmi et al. (2005) found that in Finnish hospitals, significant physiological deterioration is common several hours before a cardiac arrest. Similarly, Ludikhuize et al. (2012) found that in 81% of cases in which patients died unexpectedly or underwent another severe adverse event, the event could have been identified beforehand; half of the patients showed clear signs of deterioration 25 hours before the event. Studies from both Finland and other countries highlight the importance of regular observation of critically ill patients in order to prevent cardiac arrests, deaths, and unanticipated admissions to intensive care units (DeVita et al., 2010; Resuscitation: Current Care Guidelines Abstract, 2016; Skrifvars et al., 2006; Soar et al., 2015). The Finnish national resuscitation guidelines (Resuscitation: Current Care Guidelines Abstract, 2016), which are based on the European Resuscitation Council guidelines (2015) and scientific evidence published by the International Liaison Committee on Resuscitation, strongly emphasise the importance of the identification of patients at risk for cardiac arrest in hospitals.

Nursing is a global profession, and the need for high competence among nurses transcends national boundaries (Kajander-Unkuri et al., 2013). Clinical reasoning is an essential competency for professional nurses. Nurses' autonomy and, thus, responsibility for patient care has increased, requiring the efficient use of clinical reasoning to make decisions, often independently, in complex situations

(Simmons, 2010). Clinical competence is a key element in safe patient care, and nurses are expected to show a high degree of competence in the systematic assessment of patients' care needs (Health Care Act 1326/2010, 52 §). Clinical reasoning is fundamental in recognising patient deterioration. Using a systematic approach to observe vital signs helps nurses to distinguish changes in a patient's condition and make clinical decisions (Petit dit Dariel et al., 2013; Stafsetha et al., 2016). Ensuring patient safety is a fundamental ethical requirement for professional nurses (Act on Health Care Professionals 559/1994), and it must be taken into account in all healthcare education (Sosiaali- ja terveysministeriö, 2009).

In Finland, the number of qualified nurses increased in the 2000s. In 2011, there were 77 200 employed, qualified nurses, of which 35 230 worked in hospital services (Ailasmaa, 2014). Finnish nurses must complete a bachelor's degree at a university of applied sciences in a 3.5-year program consisting of 210 credits. The degree qualifies the graduate as a registered nurse. According to Kajander-Unkuri et al. (2013), in order to provide safe and high-quality patient care, graduating nursing students must display adequate levels of competence. They are expected to develop clinical reasoning skills during their education; to this end, nursing curricula in Finland consist of 30 credits in 'evidence-based practice and decision making', of which five credits focus on clinical reasoning (Eriksson et al., 2015). Additionally, students practice clinical reasoning in theoretical and practical contexts throughout their educations.

Nursing students have made positive assessments of their competence in detecting changes in patients' conditions (Kajander-Unkuri et al., 2014b). However, Bogossian et al. (2014) found that final-year nursing students lack the knowledge, clinical skills, teamwork and situational awareness required to manage a deteriorating patient. Similar results have been reported in Finland. For example, Lankinen (2013) found that graduating nursing students have deficiencies, especially in decision-making competence and clinical competence related to acute nursing care. Kajander-Unkuri et al. (2013) state that the competence of graduating nursing students is crucial in maintaining professional standards, patient safety and the quality of nursing care. Educational organisations need to more effectively enable the development of clinical reasoning, problem solving and critical thinking in their programmes and prepare nursing students to demonstrate critical and analytical thinking and to practice safely and effectively (WHO, 2009). Kajander-Unkuri et al. (2013) have identified eight main competence categories for nursing students in Europe. Three of these are related to clinical reasoning. The first is competence in nursing skills and intervention: nursing students should have the skills and knowledge to plan appropriate nursing actions and carry out those actions effectively and flexibly. The second category is competence in knowledge and cognitive abilities: students should be able to analyse, judge and think critically, have relevant knowledge and be able to apply this knowledge appropriately in nursing practice and patient care. The third is competence in assessment and improving quality in nursing: students should be capable of observing and diagnosing patient needs effectively, recognising risk factors, identifying and gathering evidence on care activities and prioritising and evaluating care.

Educating healthcare professionals is essential in the recognition, monitoring and management of the critically ill patient and in preventing severe adverse events (Soar, 2015). Previous studies have demonstrated the variety of learning methods that have been applied to offer undergraduate students opportunities to practice clinical reasoning (Cant & Cooper, 2010; Forneris et al., 2015; Gonzol & Newby, 2013; Lapkin & Lewett-Jones, 2011; Harmon & Thompson, 2015; Young, 2012; Young & Jung, 2015). However, research has consistently shown that nurses lack knowledge and skills in recognising patient deterioration (Kim et al., 2015; Ludikhuize et al., 2012; Soar et al., 2015; van Galen et al., 2016). Evidence addressing the impact of specific educational interventions is lacking (Soar, 2015). There is an urgent need to develop and evaluate new possibilities for learning the crucial competence area of clinical reasoning.

Educational strategies improve students' knowledge regarding managing a deteriorating patient, and opportunities for students to integrate this knowledge should be embedded in curricula (Bogossian et al., 2014). Digitalisation in higher education is increasing; the use of virtual simulations, and, recently, serious games in support of professional learning and competence development is growing, especially in healthcare education (Cant & Cooper, 2014; de Freitas, 2007; Forsberg et al., 2011; Graafland et al., 2012; Petit dit Dariel et al., 2013). Learning methods that reproduce reality allow students to practice and learn to recognise signs of deterioration in an immersive virtual environment without compromising patient safety (Dev et al., 2011; Foronda et al., 2014; Heinrichs et al., 2008; Zary et al., 2006); opportunities presented by virtual technology have been recommended for increased use in education (Sosiaali-ja terveysministeriö, 2012). Recent studies in Finland have confirmed the usefulness of virtual simulations in nursing education (Poikela et al., 2015; Virtanen et al., 2015). Additionally, Poikela et al. (2015) suggest that, to provide the greatest educational benefit for nursing students, computer-based simulations should be used alongside other learning methods.

This study highlights learners' personal experiences in their own processes of inquiry and understanding (Kolb, 1984). Very little is known about how nursing students learn by playing games or about what elements in a simulation game support their learning. The aim of the study was to obtain knowledge of learning clinical reasoning through game-based simulation; this knowledge was to be used in developing and embedding new learning methods for clinical reasoning in nursing education. There is insufficient understanding of design principles among the individuals and organisations that develop or implement simulation games for healthcare education (see Graafland et al., 2014). Thus, this study generated design principles for simulation games and used these principles in the design and development of a game for learning clinical reasoning. In developing this game, the study investigated how nursing students can learn through gaming. Throughout this dissertation, the term 'clinical reasoning' will be used to refer to a logical, dynamic and ongoing process that includes six phases: collecting information, processing information, identifying problems and issues, establishing goals, taking actions and evaluating outcomes (Lewett-Jones et al., 2010; Simmons, 2010; Tanner, 2006). The term 'game-based simulation' will be used to refer to a learning method that combines game elements, simulations and learning objectives. The present study focuses on game-based simulation delivered in web-based, mobile or virtual-reality learning environments. In this study, the term 'simulation games' will be used to refer to artefacts (software) that replicate decision making processes in real-world situations. Simulation games have three components: game, simulation, and role (Kriz, 2011 in Kurbjuhn, 2012).

This study used the design-based research methodology (see Amiel & Reeves, 2008; Barab & Squire, 2004; Sandoval & Bell, 2004; Wang & Hannafin, 2005). It was conducted as a part of the Health Care and Nursing Learning Environment Development and Research Project (2011–2013) at the Helsinki Metropolia University of Applied Sciences. The project aimed to reform learning from the viewpoint of six learning environments: simulation, drug management, evidence-based practice, digital learning, self-directed learning and health promotion. One of its aims was to develop self-directed learning environments in which students can practice clinical skills independently, without teachers' guidance and supervision. However, despite originating in the broader project, the present study was self-contained. Design-based research methodology was used because this study aimed to generate design principles that could inform the future development and implementation of educational games for the healthcare field (Reeves et al., 2005; Reeves, 2006). Design-based research is typically used to study innovative learning environments, including the use of new educational technologies, in a classroom setting (Design-Based Research Collective, 2003; Sandoval & Bell, 2004). Thus, this methodology was well suited to the present study, which used iterative cycles to design, test and evaluate a game (see Rizzo et al., 2011). In game design and development, it is important that researchers, educators, students and game designers work in collaboration. As a result, this study was multidisciplinary, involving knowledge of nursing science, educational science, technological science and game design (see Sandoval & Bell, 2004).

This study followed the phases of design-based research, and its overall structure took the form of phases of the design-based research process in chronological order. In chapter two, the theoretical framework of this dissertation is introduced, including an analysis of the practical problems to which this dissertation seeks answers. In chapter three, the aims, purposes and research questions of the study are presented. In chapter four, the design-based research process is described in detail. This includes the development of the simulation game, the use of iterative cycles to test and refine the game and, finally, the use of reflection to produce design principles for simulation games (see Amiel & Reeves, 2008; Wang & Hannafin, 2005). Qualitative and quantitative methods were used (Wang & Hannafin, 2005). The data consisted of audio and video recordings from gaming sessions, user testing and focus group interviews, as well as questionnaires. In total, 174 nursing students and 60 nurses participated in the gaming sessions. The results reported in the individual articles (Articles I–IV) were integrated into the research phases since each set of results influenced the phases that followed. Finally, in chapter five, the results, ethical considerations and limitations of the study, as well as the implications for education and future research, are discussed.

2 Theoretical framework

In this chapter, the theoretical background of the present study is introduced. The main concepts used in this study were clinical reasoning, learning, game-based simulation, simulation games, design principles and design-based research. The key concepts will be introduced by reflecting on the results of previous studies and are presented as the theoretical framework of the present study.

2.1 Learning clinical reasoning

2.1.1 Definition of clinical reasoning

The concepts of decision making, problem solving, clinical judgement, diagnostic reasoning, clinical reasoning and critical thinking have been used synonymously in the nursing literature (Lewett-Jones, 2010; Tanner, 2006; Simmons, 2010). Simmons (2010) argues that decision making, problem solving and clinical judgement refer to an endpoint in the thinking process whereas diagnostic reasoning and clinical reasoning emphasise the cognitive processes involved prior to the endpoint. Simmons (2010) defines clinical reasoning ‘as a complex process that uses formal and informal thinking strategies to gather and analyse patient information, evaluate the significance of this information and weigh alternative actions’. Tanner (2006) uses the concept of ‘clinical judgement’ to describe the problem-solving process which begins with assessment and making a nursing diagnosis, proceeds with planning and implementing nursing interventions and culminates in the evaluation of the effectiveness of the interventions. Lewett-Jones et al. (2010) define clinical reasoning ‘as a logical process, by which nurses collect cues, process the information, come to an understanding of a patient problem or situation, plan and implement interventions, evaluate outcomes, and reflect on and learn from the process’. Tanner (2006) uses the concept of clinical reasoning to describe the process by which nurses make their judgements; this includes the intentional process of producing alternatives, weighing them against evidence and selecting the most appropriate option. According to Simmons (2010), events that precede clinical reasoning include reception of cues, cognitive perception and the application of knowledge, experience, education and memory; events that follow clinical reasoning include making a judgment, deciding upon an action, taking action, making choices, inferring conclusions and evaluating outcomes.

In the clinical reasoning cycle, the circle represents the ongoing nature of clinical encounters and the importance of evaluation and reflection (Lewett-Jones et al., 2010). Clinical reasoning guides nurses in assessing, adopting, retrieving and discarding information that affects patient care (Simmons, 2010). Clinical reasoning is a dynamic and recursive process, and nurses often combine one or more phases or move back and forth between them while adding, deleting or re-evaluating information before reaching a decision, taking action and evaluating outcomes (Lewett-Jones et al., 2010; Simmons, 2010). During the clinical reasoning process, a nurse can flexibly assess cues, apply knowledge and experience and evaluate the relevance and value of the data collected as well as the relevant interventions (Simmons, 2010).

Considering all of this evidence, ‘clinical reasoning’ is defined in this study as a logical, dynamic and ongoing process that includes the following phases:

1. Collecting information: assessing cues, gathering patient information, making a clinical assessment (Lewett-Jones et al., 2010; Simmons, 2010; Tanner, 2006).
2. Processing information: evaluating the significance of the information, processing the information to produce alternatives and weigh them against evidence, evaluating the relevance and value of the data collected (Lewett-Jones et al., 2010; Simmons, 2010; Tanner, 2006).
3. Identifying problems/issues: coming to an understanding of a patient’s problem or situation, making an interpretation or conclusion about the patient’s needs, making a nursing diagnosis (Lewett-Jones et al., 2010; Tanner, 2006).
4. Establishing goals: planning implementation, selecting the most appropriate intervention (Lewett-Jones et al., 2010; Tanner, 2006).
5. Taking action: deciding to take action, implementing the relevant interventions (Lewett-Jones et al., 2010; Simmons, 2010; Tanner, 2006).
6. Evaluating outcomes: evaluating the effectiveness of the intervention (Lewett-Jones et al., 2010; Tanner, 2006).

Clinical reasoning includes cognition (thinking), metacognition (reflective thinking) and discipline-specific knowledge (Simmons, 2010). Nurses use a variety of reasoning patterns alone or in combination (Tanner, 2006), and depending on the clinical situation and the experience of the nurse, formal strategies or informal strategies are used in clinical reasoning (Lauri et al., 2001; Simmons, 2010). According to Lauri et al. (2001), in making most decisions, nurses use both analytical and intuitive cognitive processes. Analytical cognitive processes are emphasised in information collection, problem definition and planning of care whereas intuitive cognitive processes are emphasised in implementing and evaluating care.

Clinical reasoning is influenced by the context of the situation (Lauri et al., 2001; McCarthy, 2003; Simmons, 2010; Tanner, 2006) and knowledge of the patient as well as a nurse’s personal characteristics (McCarthy, 2003; Simmons, 2010; Tanner, 2006). Lauri et al. (2001) found that nurses in long-term care are analytically oriented decision makers while nurses in acute care are intuitively oriented. McCarthy (2003) argues that nurses in home settings feel more obligated to identify and solve problems than nurses in acute care or long-term care settings. The acute care environment facilitates less accurate decisions due to lack of connectedness with patients. Having limited time in which to make decisions, implement them and then evaluate the consequences also interferes with clinical reasoning (O'Neill et al., 2005). In addition, acute stress may represent a risk factor for inaccurate clinical reasoning and for diagnostic errors (Pottier et al., 2013). According to McCarthy (2003), nurses' personal values influence their clinical reasoning ability more than the care environment, and autonomy, responsibility and accountability for patient care enhance nurses' ability to reason clinically.

Novice and expert nurses use different thinking strategies while caring for patients in real-world situations. According to Hoffman et al. (2009), expert nurses collect more clues from a larger amount of information than novice nurses do. They also relate more cues to each other than novices and are better able to prevent patient complications. Forsberg et al. (2014) have found that clinically experienced nurses make hypotheses about nursing diagnoses then test and reinforce their hypotheses by analysing patient data. Experts reason from a deductive perspective, which is affected by strong, specific clinical knowledge and experience (Forsberg et al., 2014) whereas novices search for patient cues and information once they have actually identified a patient's problem (Hoffman et al., 2009). Andersson et al. (2012) have found that novice nurses use task-oriented and action-oriented approaches to clinical reasoning. Task-oriented nurses rarely consider causes and effects. In an action-oriented approach, the conclusions, suggested actions and planning are structured and made without deeper analysis of the patient case. O'Neill et al. (2005) argue that cognitive processing for the novice nurse is deliberate and rule-driven and that novice nurses' clinical reasoning is limited because their perception of the clinical situation is restricted and tends to be focused on one problem only.

2.1.2 Methods for learning clinical reasoning

Various methods for learning clinical reasoning have been applied in nursing education. Nursing students need to learn how to synthesise and analyse facts to identify clinically at-risk patients, make definitive nursing diagnoses and select courses of action (Kajander-Unkuri et al., 2013; Lewett & Jones, 2010). The development of clinical reasoning in novice nurses happens over time and includes the transformation of theoretical knowledge to experiential knowledge (O'Neill et al., 2005). The advancement of skills and competencies is developmental and, thus, opportunities to practice them over time are necessary (Furze et al., 2015). Essential components associated with learning clinical reasoning include gaining confidence in one's skills, building relationships with staff, connecting with patients, gaining comfort in oneself as a nurse and understanding the clinical picture (White, 2003). According to Kuiper and Pesut (2004), reflective clinical reasoning in nursing practice depends on the development of both cognitive (critical thinking) and metacognitive (reflective thinking) skill acquisition. They argue that self-evaluation is a key factor in reflection, which influences critical thinking and the development of clinical reasoning skills. According to Bulman et al. (2012), self-reflection is connected to professional development. Guiding and supporting the reflective process promotes greater levels of reflectivity, and reflective thinking skills develop in varying degrees depending on the individual subject and support from educators (Kuiper & Pesut, 2004).

Previous research has established that using a reasoning model while teaching psychomotor skills in a skills laboratory can help nursing students to greatly improve their reasoning (Gonzol & Newby, 2013). In another study, Harmon and Thompson (2015) found that collaborative activities in which students use medical-surgical case studies to practice processing information increased the students' skills in clinical reasoning. It has also been found that students learn reasoning in clinical practice by working alongside professionals who encourage participation in active decision making (Young, 2012). It has been well established by a variety of studies that simulation-based learning enables students to learn clinical reasoning (Cant & Cooper, 2010; Forneris et al., 2015; Jensen, 2013; Lapkin et al., 2010, Lapkin & Lewett-Jones, 2011; Young & Jung, 2015; Pottier et al., 2013). Simulation scenarios can realistically be used to recreate the clinical setting's affective components, such as stress (Pottier et al., 2013). However, stress can also be a challenge for students. Students may be intimidated by the simulation, being insecure in their skills and knowledge (see Keskitalo, 2012). Young and Jung (2015) assessed, using a quasi-experimental design, the effects of a one-time simulation experience on nursing students' knowledge acquisition, clinical reasoning skills and self-confidence and found that students in the simulation group scored significantly higher in terms of clinical reasoning skills and related knowledge than did those in the didactic lecture group. Lapkin et al. (2010) conducted a systematic review in order to identify the effectiveness of using human patient simulation manikins (HPSMs) in teaching clinical reasoning to undergraduate nursing students. They found that none of the studies were specifically designed to evaluate the effectiveness of using HPSMs for clinical reasoning. However, they found that the use of HPMSs significantly improved three outcomes integral to clinical reasoning: knowledge acquisition, critical thinking and the ability to identify deteriorating patients. Jensen (2013) found that students were able to demonstrate adequate levels of clinical reasoning during simulated patient care. Debriefing after a simulation allows students to reflect on the results of their actions and performance regarding patient care, to analyse mistakes that could be avoided in similar situations in the future (Teixeira et al., 2015) and, thus, to learn clinical reasoning in a meaningful way (Forneris et al., 2015).

2.2 Game-based simulation for learning clinical reasoning

The past decade has seen the rapid development of technology, and its effects on education are clearly visible. Recently, a considerable literature has developed around the topic of simulations carried out in virtual environments, and different terms are used when referring to them. To mention a few of these terms: 'screen-based simulator' (e.g. Gaba, 2007), 'virtual patient' (e.g. Forsberg et al., 2011), 'virtual reality simulation' (e.g. Smith & Hamilton, 2015), 'virtual patient cases' (e.g. Benedict et al., 2013), 'virtual patient simulation' (Botezatu et al., 2010), 'web-based simulation' (e.g. Cant & Cooper, 2014), and 'computer-based simulation' (e.g. Poikela et al., 2015). These terms emphasise the simulation component. Most also include the term 'virtual'. The growing popularity of video games has led to increased interest in gamifying education (Hamari et al., 2014), however, this is either not yet reflected in the terminology used in healthcare literature when referring to the combination of simulation and game elements or, more probably, game elements are not widely applied to simulations in virtual environments. Some studies have used the term 'serious games' with emphasis on the gaming aspect (e.g. Graafland et al., 2012). This study places particular emphasis on the integration of game elements and virtual simulations and the educational aspects of such games. For these reasons, this study uses the term 'game-based simulation'.

In this chapter, the concept of a game-based simulation is defined, and its use as a method for learning clinical reasoning is presented. The elements considered important when learning clinical reasoning through a game-based simulation are introduced. Learning clinical reasoning through game-based simulations is a recent innovation. In order to obtain the most comprehensive picture of this phenomenon, the review of the current literature includes studies that are qualitatively very different from one another.

2.2.1 Game-based simulation

The use of 'serious games' in healthcare is growing. 'Serious games' are games used for purposes other than solely entertainment (Susi et al., 2007). In healthcare, serious games are used in health promotion (e.g. Sturm et al., 2014), prevention (e.g. Falco et al., 2014), early diagnosis, therapy (e.g. Deen et al., 2014) and rehabilitation (e.g. Burke, 2009). One important use is professional training (Cant & Cooper, 2014; Forsberg et al., 2011; Graafland et al., 2012; Petit dit Dariel et al., 2013). Serious games lie at the intersection between leisure games and educational simulations (de Freitas, 2006; Taekman & Shelley, 2010). Such games commonly focus on problem solving (Susi et al., 2007). In serious games, game aspects (entertainment value) and educational aspects need to be in balance (Kurbjuhn, 2012). The majority of serious games used for educational purposes are simulations, with health disciplines being the most popular field (Connolly et al., 2012). As an illustration of this, computer and web-enabled simulations are well established in anaesthesiology training and have proven to be effective learning tools (Lampotang, 2008). First aid is the field with the highest number of developed games (Ricciardi & De Paolis, 2014). Simulation games can be classified as serious games, but not all serious games are simulation games (Kurbjuhn, 2012). In contrast, Becker and Parker (2011) state that all computer games are simulations because they are based on models and they simulate the passage of time. However, not all computer games simulate or model reality, for example quiz-games. According to Kurbjuhn (2012) serious games is a more general term, whereas simulation games are related to reality because they concentrate on the simplification of existent problems in reality.

Simulation games are built on realistic scenarios and precise processes in order to transfer knowledge (Kurbjuhn, 2012). Simulation games have three components: game, simulation, and role (Kriz, 2011 in Kurbjuhn, 2012). Games have four basic interrelated elements: mechanics, story, aesthetics, and technology (Schell, 2014). Mechanics are the procedures and rules of the game, including the goal to be achieved. Story is the sequence of events in the game, and aesthetics are how the game looks and sounds. Technology refers to any material or interaction device (from paper to VR glasses) that ties mechanics, story, and aesthetics together into a game.

Games offer an isolated arena in which the players can act freely (Kurbjuhn, 2012). In an educational context, learning objectives are integrated into game characteristics such as goals, conflicts, rules, interactions, and challenges (Hamari et al., 2014; Schell, 2014). De Freitas (2007) defines ‘games for learning’ as ‘applications using the characteristics of video and computer games to create engaging and immersive learning experiences for delivering specified learning goals, outcomes and experiences’. Connolly et al. (2012) found that the most popular platform for the delivery of games used for educational purposes was the personal computer, followed by video games played on consoles and online gaming.

Simulations are situations that replicate actual or probable real life conditions or events, and they are used to predict the behaviour of complex systems in situations where simply trying something out is too expensive or dangerous (Becker & Parker, 2011). According to Gaba (2004), ‘simulation is a technique, not a technology, to replace or amplify real experiences with guided experiences, often immersive in nature, that evoke or replicate substantial aspects of the real world in a fully interactive fashion’. A role is a function that a participant takes on in a game (Kriz, 2011 in Kurbjuhn, 2012), and in healthcare simulation games, the learners take on the roles of professionals.

In a later study, Gaba (2007) divided technologies relevant for simulations into three types: mannequin-based simulators, screen-based simulators, and virtual reality simulators. In the last two, the patient and environment are presented to the learner through two- or three-dimensional visual and audio representations. Haptic simulators recreate the sense of touch and create a more immersive learning experience. A computer simulation is a way of modelling a real-world situation using computers, mobile devices, virtual reality systems, or simulators (Becker & Parker, 2011; de Freitas, 2007). Computer simulations have been used mostly for learning cognitive skills, clinical management skills, and interpersonal skills (Alinier, 2007). In order to emphasise the current era of digitalisation, in which mobile devices, virtual reality, and augmented reality devices are increasingly used for learning purposes, this study uses the term 'virtual simulation', rather than computer simulation.

Virtual simulations can be grouped into two types: experimental and experiential (Becker & Parker, 2011). Experimental simulations are focused on seeking answers to questions, whereas experiential simulations provide an environment with which users can interact. A learner's experience can be strengthened by adding game elements to the simulation. This act of enhancing a simulation or service with game-like features is called gamification (Hamari et al., 2014). Gamification has three main parts: implemented motivational affordances, psychological outcomes, and behavioural outcomes. Motivational affordances can include points, leaderboards, achievements/badges, levels, stories/themes, goals, feedback, rewards, progress, and/or challenges. Psychological outcomes include satisfaction, engagement, motivation, attitude, and enjoyment. Behavioural outcomes are measurable variables such as the quality of completed tasks, task completion speed, and increased knowledge or learning outcomes.

A variety of studies have established that virtual simulations have a positive effect on nursing students' learning (Virtanen et al., 2013; Foronda et al., 2016; Poikela et al., 2015). According to Petit dit Dariel et al. (2013), the benefit of combining games and simulations is that games can provide far more complex scenarios than laboratory simulations can. However, there are potential problems with simulation-based learning. One concern is the possible drift towards technology rather than pedagogy (Bland et al., 2011); advancements in technology and educators' enthusiasm to adopt them may displace the use of learning theories and pedagogy when learning with simulations. Also, complex new technology and equipment may require time to master, making educators less willing to use technology-enhanced learning environments. Other challenges include the maintenance and transference of knowledge and skills gained in simulations to a hospital environment and the integration of simulations into curricula. McGaghie et al. (2010) present twelve features and best practices simulation-based medical education that should be followed in order to maximise the educational benefit of simulations. These include, for example, feedback, curriculum integration, simulation fidelity, skill acquisition and maintenance, transfer to practice, and educational and professional contexts.

Learning in virtual worlds changes the focus of education from traditional teacher-centred knowledge sharing to student-centred, immersive learning experiences (de Freitas et al., 2010). Greater emphasis is put on learning as a process rather than on specified learning objectives and outcomes (de Freitas, 2007). In nurses' professional development, learning is often experiential in nature. For experiential learning to be effective, learners need the opportunity to learn or acquire four things: concrete experience, reflective observation, abstract conceptualisation and active experimentation (Kolb, 1984). Games are virtual fields of practice that provide players with opportunities for problem solving and skill performance in a controlled setting (Bauman, 2012). According to Kolb (1984), learners must involve themselves fully and with open minds in new experiences, be able to reflect on and observe those experiences from multiple perspectives, be able to create concepts that integrate their observations into logically sound theories and be able to use theories to make decisions and solve problems. Games can be an ideal space for experiential learning to occur and a step towards actual practice. By experiencing concrete realities in game worlds, learners can understand complex concepts without losing sight of the connection between abstract ideas and the real problems that they must solve (Shaffer et al., 2005).

Hamari et al. (2016) state that educational games can effectively engage students in learning activities because such games have positive effects on concentration, interest, and enjoyment. Challenges during game play predict learning outcomes (Hamari et al., 2016), and educational games should provide challenging tasks that enable knowledge construction (Kiili et al., 2012). Oksanen (2013) reports similar results, indicating that players' engagement in a game depends on meaningful and challenging tasks. According to Niemi and Multisilta (2015), player engagement requires both hard work and fun. Engaging tasks lead players to put more effort into the tasks' completion (Kiili et al., 2012).

The common core of educational simulations and games is designed to create personal experiences for learners in support of their processes of inquiry and understanding (Kolb, 1984). Games are important for learning because they enable learners to participate in new worlds by thinking, acting and inhabiting roles that would otherwise remain inaccessible (Shaffer et al., 2005). Games not only tell a story but allow people to actively live it (Rigby & Ryan, 2011). In well-designed serious games, action-reflection cycles are embedded in the game mechanics. Games offer designed experiences in which students learn through doing and being, based on the assumption that learners are active constructors of meaning with their own goals and motivations (Squire, 2006); in game worlds, students develop new ways of thinking, knowing, being and caring (Shaffer et al., 2005).

According to Connolly et al. (2012), the most frequently occurring outcomes and impacts of playing computer games are knowledge acquisition, content understanding and affective and motivational outcomes. Rosser et al. (2007) investigated the link between video game play and laparoscopic surgical skill and suturing, and they found that video game skill and past video game experience (consisting of at least three hours of play per week) have a significant impact on laparoscopic skills. Video game players make fewer mistakes and perform faster than nonplayers. Virtanen et al. (2013) found that different learners from different backgrounds are able to use computer simulations to manage their own learning. Further, their results showed that using a computer simulation suited both students who expected external regulation of the learning process and students who handled their own learning process. Several studies have reported that students find virtual simulations engaging and motivating (Benedict et al., 2013; Verkuyl et al., 2016; Wilson, 2012; Zary et al., 2006). Additionally, it has been found that virtual simulations results in better knowledge retention than traditional learning methods (Botezatu et al., 2010). Moreover, LeFlore et al. (2012) found that nursing students receiving paediatric respiratory disease content using virtual training have significantly higher knowledge acquisition and better knowledge application than students in the traditional lecture group. Studies have also shown that students find virtual simulations more realistic than paper-pencil cases (Zary et al., 2006) and outstanding when compared to other online methods and face-to-face methods of learning (Wiecha et al., 2010). This may be due to the fact that learning through games is more experiential and less structured than more traditional, text-based learning (de Freitas & Neumann, 2009). In a study by Benedict et al. (2013), students felt that completion of virtual cases prior to face-to-face lessons enabled more efficient use of class time and, thus, supported students in becoming more self-directed learners. In addition, learners value working at their own pace (Taekman & Shelley, 2010; Wu et al., 2012; Zary et al., 2006).

There are also challenges in using games in educational purposes. de Freitas et al. (2010) found that learners who are unfamiliar with 3D environments do not benefit from the virtual learning experience. These researchers also found that the younger generation of learners adapts to new approaches more rapidly because of their experience with online gaming. Supporting these assertions, Oksanen (2013) found that active gamers feel a higher degree of competence that learners who play less frequently. However, de Freitas et al. (2010) state that prior experience of gaming may have negative impacts on learning with virtual world applications since regular gamers have high expectations for fidelity and interaction, which students in virtual worlds have reported to be poor. In addition, regular gamers are accustomed to structured and goal-oriented activities, and if the virtual environment is unstructured and open-ended, they might find it difficult to use.

The present study adopts the following definition of 'game-based simulation': a learning method that combines game elements, simulations, and learning objectives and focuses on game-based simulations delivered in web-based, mobile, or virtual-reality learning environments. For present purposes, the term 'simulation games' will be used to refer to artefacts (software) that replicate decision making processes in real-world situations. This study adopts the standpoint of Kriz (2011 in Kurbjuhn, 2012) that simulation games have three components: game, simulation, and role.

The context of this study is learning in nursing education. Educational simulation games refers here to games that are designed for educational purposes and serve certain learning objectives. The study focuses on experiential simulations in which the learner interacts with the virtual patient and the hospital environment (see Becker & Parker, 2011). In this study, 'game elements' refers to story, visual representation and cues, goals, scores, feedback, rewards, progress, and challenges, which are used to stimulate and maintain learners' motivation (Hamari et al., 2014). In the context of this study, learners take on the roles of nursing professionals.

2.2.2 Learning clinical reasoning by game-based simulation

Game-based simulation is associated with learning clinical reasoning (Cook et al., 2010; Forsberg et al., 2011; Wilson, 2012; White, 2012). In games, players must generally solve various problems and overcome challenges (Schell, 2014). Thus, clinical reasoning can be understood as a problem-solving activity (Tanner, 2006). The thinking process when playing games have similarities when comparing to the clinical reasoning process. They both are ongoing problem-solving activity where the learner identifies problems, sets goals to solve them, takes action, receives feedback and reflects on that feedback (Bauman, 2012). By engaging students in clinical scenarios, experiential learning techniques can promote clinical reasoning skills (Hart et al., 2014).

Even though most simulation-based nursing e-learning programmes focus on teaching procedural skills (Cant & Cooper, 2014), there is some evidence that simulation games could be applied to learn clinical reasoning (Forsberg et al., 2011; Lewett-Jones et al., 2010; Petit dit Dariel et al., 2013). The phases and steps in the clinical reasoning model can provide an approach that can be used in computerised simulations (Lewett-Jones et al., 2010). Petit dit Dariel et al. (2013) embedded the clinical reasoning model in the serious game scenario, offering a variety of tasks to encourage the learner to consider different steps in the cycle. They found that the clinical reasoning cycle provides students with a systematic approach to following the steps of the clinical reasoning process. The researchers assumed that, through their interactions with the virtual patient and the environment, learners will begin to systemically apply clinical reasoning and practice prioritising interventions. However, Secomb et al. (2012) argue that simulation-based education does not produce higher-order thinkers in clinical practice. They found that either computer-based or laboratory-based simulation had an effect on undergraduate nursing students' ability to make clinical decisions in practice.

Zary et al. (2006) highlight three important elements for learning clinical reasoning by using virtual simulations. First, virtual cases enable students to test their knowledge and identify learning needs. Second, virtual simulations promote information processing by requiring students to go through the clinical reasoning process. Third, cases support reflective thinking by providing feedback on performance. Game-based simulation prepares students for real-life situations (de Freitas & Neumann, 2009; Heinrich et al., 2012; Ulrich et al., 2014; Wilson, 2012) and thus, helps them to build confidence (de Freitas & Neumann, 2009; McCallum et al., 2011; Wilson, 2012). The simulation environment provides the same clinical content and situations to all students, enabling equal learning opportunities for all (Zary et al., 2006).

The benefit of game-based simulation over classroom simulation is that the former can be duplicated and distributed to an unlimited number of learners at any time and in any place (Taekman & Shelley, 2010; Zary et al., 2006). The use of virtual simulations is also supported by research evidence, which shows that face-to-face and virtual clinical simulations produce similar learning outcomes (Cobbett & Snelgrove-Clarke, 2016). In addition, delivering simulations in a classroom setting is expensive and time-consuming, requiring physical space and personnel resources (Alinier, 2011; Zigmont et al., 2011). Online self-study, accompanied by face-to-face teaching, offers an effective and attractive educational solution for acute care and significantly reduces training costs (Dankbaar et al., 2014). A study by Poikela et al. (2015) showed that nursing students can experience meaningful learning through computer-based simulation programmes and can transfer the knowledge and skills gained through computer-based simulation to classroom simulation. However, embedding serious games in nursing curricula is insufficient (Ricciardi & De Paolis, 2014; Zary et al., 2006). There is not much evidence regarding how students learn clinical reasoning through gaming or which elements in a game support learning. Nevertheless, game-based simulation offers an ideal teaching method for students before they are entrusted with the care of real patients in supervised clinical practice (Graafland et al., 2012).

2.2.3 Elements supporting learning clinical reasoning by game-based simulation

The elements considered to be important for learning clinical reasoning by game-based simulation will be introduced in the following paragraphs by reflecting on the results of previous studies. In the present study, the elements considered important for learning clinical reasoning by playing games are as follows: authentic representation of clinical practice; active participation in patient care; application of nursing knowledge; exploration; feedback; reflection; collaborative gaming; and usability.

Authentic representation of clinical practice (Bland et al., 2014; Huwendiek et al., 2009; Verkuyl et al., 2016) and the authenticity and reliability of patient scenarios (Forsberg et al., 2011; Guise et al., 2012; Honey et al., 2012; Huwendiek et al., 2009; LeFlore et al., 2012; Rizzo et al., 2011) are important when considering the educational value of a simulation. Educators have found that virtual simulations bring authenticity to learning and are, thus, beneficial for providing experiential learning opportunities for students (Keskitalo, 2011). The increased level of realism in serious games, which is reached by high-quality game development environments, can improve the transfer of learning from the simulated situation to a real-life context (de Freitas & Neumann, 2009). Believable scenarios correspond to real-life situations, but as Dev et al. (2011) state, they require medically important interactive objects and typical medical clues. Rizzo et al. (2011) argue that 'the behaviour of the virtual patient should match the behaviour one would expect from a patient in such a condition'. According to Bland et al. (2014), 'authenticity in the context of simulated learning is associated with realism of which fidelity is a potential attribute'. Lapkin and Lewett-Jones (2011) define fidelity in a simulation experience as authenticity or lifelikeness. Bland et al. (2014), in turn, refer to fidelity as the reproduction of an objective reality and authenticity as the subjective and highly individual interpretation of a simulated situation. They argue that increasing fidelity through technology does not guarantee authenticity of simulation-based learning and that authenticity can be produced with low fidelity. A learner's virtual experience consists of how he interacts with the virtual environment (de Freitas & Neumann, 2009), and the lack of responsive virtual patients decreases realism (Dev et al., 2011). Some students may have difficulty engaging with an environment of imperfect fidelity, and this may crate barriers for learning complex clinical practice and social interaction skills (Bland et al., 2014). Research shows that students' negative experiences with virtual simulations are connected to lack of authenticity and clinical realism in the scenarios (Forsberg et al., 2011; Hurst et al., 2011; Roh et al., 2013).

Active participation in patient care provides opportunities for nursing students to practice decision making and, thus, become more confident (McCallum et al., 2011). Learning through games requires that learners can be active agents (Gee, 2005). In virtual simulations, students can become actively involved with the patient and the situation (Guise et al., 2012; Heinrich et al., 2012). McCallum et al. (2011) found that students may not have the opportunity to make decisions in clinical placement, and this lack of opportunity may lead to uncertainty regarding the skills required to make decisions. In a game, the learner can make a range of decisions, leading to a limitless number of paths as determined by the game engine and, thus, making the complex decision-making process visible to the students (Petit dit Dariel et al., 2013). Zary et al. (2006) state that students value the ability to freely make decisions regarding patient examination and diagnosis.

Application of nursing knowledge during gaming bridges the gap between theory and practice. Simulations in general enable the application of knowledge and the learning of clinical reasoning by putting theory into practice (Lewett-Jones et al., 2011). Through games, nursing students can apply previously acquired theoretical and practical knowledge, as well as experiences with patient care, in order to resolve patient scenarios (Blakely et al., 2009; Forsberg et al., 2011; Lewett-Jones et al., 2011; McCallum et al., 2011). McCallum et al. (2011) found that students make decisions based on theories they have learned and experiences they have gained during clinical practice. Nursing students have reported that virtual cases force them to consider what is important and, thus, allow them to apply their knowledge and skills (Forsberg et al., 2011). A small scale study by Cook (2012) revealed that the most effective feature of a virtual paediatric primary care clinic constructed in Second Life® was the opportunity it presented for students to spend time with cases, use subjective and objective data to make treatment decisions and work through the diagnosis.

Exploration here refers to attempting something repeatedly during gameplay and learning from mistakes (Foronda et al., 2014; Heinrichs et al., 2008). Virtual scenarios provide a safe learning environment in which to practice clinical skills and learn from mistakes without harming real patients (Dev et al., 2011; Foronda et al., 2014; Heinrichs et al., 2008; Kidd et al., 2012; Wilson, 2012; Zary et al., 2006). Huwendiek et al. (2009) found that virtual simulations should offer repetition of key learning points and tasks. Repetition helps nursing students to internalise and automate procedures, teaching them to prioritise by making their own decisions and seeing the concrete consequences, thus preparing the students for real clinical reasoning situations (McCallum et al., 2011; Roh et al., 2013; Wilson, 2012). Games can also be used for formative and summative assessments (Taekman & Shelley, 2010). The use of virtual cases to assess clinical reasoning has been widely accepted among students (Forsberg et al., 2011).

Feedback on a student's performance is necessary in order for the student to benefit fully from the gaming experience. According to Kiili et al. (2012), the purpose of feedback systems in games is to inform players about their performance and progress. Kiili et al. (2012) divided feedback into immediate and cognitive feedback. Immediate feedback keeps players focused on the task, and cognitive feedback provides information that is important for learning by stimulating reflection. Erhel and Jamet (2013) argue that digital learning games, accompanied by feedback, help learners mobilise deep cognitive processes during learning. One important factor is the timing of the feedback (Botezatu et al., 2010). Learners favour immediate feedback on their performances (Fonseca et al., 2015; Huwendiek et al., 2009; Zary et al., 2006). Tsai et al. (2015) found that providing immediate, elaborated feedback promotes learning and that feedback, in general, significantly affects learning effectiveness. Immediate feedback provides instant evaluation to learners while elaborated feedback guides learners toward the correct answers. Feedback and guidance should be provided to learners in order to feel in control while playing (Toro-Troconis et al., 2008). Huwendiek et al. (2009) found that virtual simulation should offer feedback in the forms of questions and explanations related to the clinical reasoning process. Feedback is corrective when learners are told whether their answers are right or wrong, and it is explanatory when the game provides explanations along with the right and wrong answers (see Erhel & Jamet, 2013). Correction of errors during gameplay is associated with good learning outcomes (Ketamo & Suominen, 2010; Erhel & Jamet, 2013). On the contrary, Wilson (2012) found that learners prefer to continue in spite of their mistakes rather than being corrected since the former better reflects a real-life situation. Goldberg and Cannon-Bowers (2015) found that feedback significantly improves performance in training scenarios and structure and feedback in virtual cases allow learners to 'order their thoughts, proceed in a stepwise fashion and refine their mental models' (Wilson, 2012).

Reflection is critical for the development of clinical knowledge and improvement in clinical reasoning (Lewett-Jones et al., 2010; O'Neill et al., 2005; Tanner, 2006). In learning clinical reasoning, reflection on the process and on new learning is important. According to Lewett-Jones et al. (2010), reflection refers to contemplating what has been learned from the clinical reasoning process and what could have been done differently. Gaming provides opportunities for reflection on learning through feedback, enabling learners to construct new mental models and to discover new and better solutions to the problems encountered (Kiili, 2005). By embedding reflective activities in nursing simulation games (see Cant & Cooper, 2014; Wilson, 2012), games can provide opportunities for students to reflect on the results of their performance during and after actions (McCallum et al., 2011; Tanner, 2006; Texeira et al., 2015). While gaming, learners can reflect-in-action and reflect-on-action (see Schön, 1983). Tanner (2006) defines reflection-in-action as nurses' ability to 'read' a patient and plan their interventions based on that assessment, and she argues that much of this reflection-in-action is tacit and not obvious. Reflection-on-action, on the other hand, exposes what nurses have gained from their experiences and contributes to their ongoing clinical knowledge development and their capacity for clinical reasoning in the future (Tanner, 2006).

Virtual simulations promote reflection by allowing learners to review the content and seek more information while solving the case and making choices (Wilson, 2012). Based on feedback from the game, which tracks every action (Taekman & Shelley, 2010), learners can assess their own progress and ponder the consequences of their actions (Wilson, 2012). Georg and Zary (2014) found that nursing students used immediate feedback for reflecting and identifying knowledge and learning needs.

Collaborative gaming supports social and psychological aspects of learning (Oksanen & Hämäläinen, 2013), and working together through scenarios enables students to reflect together on the patient scenarios and clinical decisions that they have made (Wilson, 2012). Scenario-based simulation is good way to practise collaborative decision making during education because it allows students to support one another's knowledge and skill acquisition (Jeffries, 1997). Oksanen and Hämäläinen (2013) found that collaborative game-playing facilitates and supports players' socio-emotional processes. Harmon and Thompson (2015) studied whether collaborative activities are effective in improving nursing students' clinical reasoning skills. They found that students' process information together using theoretical knowledge and that their clinical reasoning skills increase significantly with collaboration. Studying with virtual cases is a social activity that allows students to learn from their peers (Wilson, 2012).

The *usability* of a game has an impact on learning by playing. The preconditions for a good educational experience using games include usability, a useful artefact and an engaging task (Kiili et al., 2012). According to Kiili et al. (2012), user experience consists of three main elements and the interaction between elements in certain context of use. The main elements are users, an artefact and a task. At the intersection of these elements are engagement, usability and usefulness. Regarding artefacts, the researchers define a useful design as a 'design of an artefact containing the right functions required for users to perform their task efficiently and to accomplish their goals'. Research has shown that ease of use increases users' desire to continue playing the game (Fonseca et al., 2015; Zhua et al., 2012). The ease of use of the game's user interface is significant in minimising the amount of cognitive energy that a player uses on navigating, helping the player to focus on learning (Zary et al., 2006). Technical problems in accessibility and usability have a significant impact on a player's learning experience since they reduce the immersiveness of the experience and, thus, the experience's effectiveness (de Freitas et al., 2010; Dev et al., 2011; Rizzo et al., 2011; Cobbett & Snelgrove-Clarke, 2016; Wilson, 2012). Perceived usefulness relates to the potential for learning clinical skills and team training (Heinrichs et al., 2010), learning clinical reasoning (Georg & Zary, 2014), practicing clinical assessment, applying theoretical knowledge, reflecting on practice, acquiring new knowledge and feeling motivated to learn (Fonseca et al., 2015).

2.3 Design-based research in generating design principles for simulation games

Design-based research is a systematic methodology that aims to improve educational practices (Wang & Hannafin, 2005). Design-based research leads to the development of knowledge that advances pragmatic and theoretical aims (Design-Based Research Collective, 2003; Wang & Hannafin, 2005). The goal of design-based research is to build a strong connection between educational research and real-world problems (Amiel & Reeves, 2008; Plomp, 2013) and to improve educational practices (Wang & Hannafin, 2005). Design-based research is similar to action research. They both aim to solve real world problems in collaboration with researchers and practitioners through cyclical research processes. However, in this study it was decided to use a design-based research methodology because it combines research and design (Sandoval & Bell, 2004), which is important when designing and developing new educational technology. Additionally, while design-based research integrates the development of solutions to practical problems, as does action research, it also identifies reusable design principles that can assist in development and implementation of solutions in the future (Plomp, 2013; Reeves et al., 2005; Reeves, 2006). The term 'design principle' refers to the theoretical yields of design research (see Plomp, 2013; Reeves, 2006). Research on design leads to theories that aid communication between practitioners and educational researchers about the relevant implications of knowledge of innovative learning environments (Design-Based Research Collective, 2003).

Design-based research can engage educators in designing learning environments that can help students to transfer their acquired knowledge and experience to real-life situations more effectively than traditional teacher-centred education (Reeves et al., 2005). Design-based research is well suited to studying technological innovations in education, such as game design, in which iterative cycles can be used to design, test and evaluate the game (see Amiel & Reeves, 2008; Plomp, 2013; Rizzo et al., 2011). Amiel and Reeves (2008) emphasise that educational technology is more than simply the technological aspects of tools. It is a process that involves interactions of humans in complex social and cultural situations. This is how educational design-based research differs from laboratory experiments, which are usually focused on a single dependent variable and are conducted in a laboratory without significant interference from other variables. In laboratory experiments, researchers try to control variables; in design-based research, researchers try to characterise a complex situation (Collins et al., 2004).

Design-based research is conducted over a long period within a single real-life setting, where learning actually happens (Amiel & Reeves, 2008; Design-Based Research Collective, 2003; Sandoval & Bell, 2004; Wang & Hannafin, 2005). In design-based research, researchers collaborate with designers, practitioners and participants to manage the research process (Amiel & Reeves, 2008; Wang & Hannafin, 2005). Researchers are committed performing research in complex real-world contexts (Amiel & Reeves, 2008). They work together with practitioners to produce change in contexts of practice, and the value of the knowledge gained through the iterative research process depends on the partnership of the participants (Design-Based Research Collective, 2003).

According to Amiel and Reeves (2008), the process begins with an analysis of practical problems and the defining of goals by the researchers and practitioners in collaboration. Practitioners should be involved in the early stages of the research process; they play an important role in identifying practical problems in teaching and learning, and research questions are derived from these problems (Amiel & Reeves, 2008; Reeves, 2006). The next phase consists of developing prototype solutions based on existing design principles and technological innovations (Amiel & Reeves, 2008; Reeves, 2006). Development of design principles includes several iterative cycles of testing and refinement of solutions in practice (Amiel & Reeves, 2008; Design-Based Research Collective, 2003; Reeves et al., 2005; Reeves, 2006; Wang & Hannafin, 2005), and findings of the previous cycle must be taken into account for the next cycle (Plomp, 2013). Iterative cycles reveal limitations throughout the process, and designers can change the design as necessary. This makes it possible to generate more transferable and useful results (Amiel & Reeves, 2008; Reeves, 2006; Wang & Hannafin, 2005). Mixed methods, including both quantitative and qualitative methods, are used, and they vary during the study’s phases, increasing the objectivity, validity, credibility and applicability of the research (Wang & Hannafin, 2005).

Rizzo et al. (2011) described the design process of intelligent virtual human patients with psychological disorders. The researchers aimed to create believable social interactions between virtual agents and novice clinicians. The development process had five phases, including defining the concept and goals for the project, developing the virtual patient system, testing the technical and nontechnical (learning content) sides of the system and evaluating students’ interviewing skills using virtual patients. However, design-based research goes beyond designing and testing particular interventions; it helps to understand the relationship among theory, designed artefacts and practice (Design-Based Research Collective, 2003).

The outcomes of design-based research are the design principles generated based on the knowledge gained through the research process (Amiel & Reeves, 2008; Reeves et al., 2005; Reeves, 2006; Wang & Hannafin, 2005). van den Akker (1999, in Plomp, 2013) distinguishes two types of design principles. Procedural design principles are characteristics of the design approach, and substantive design principles are characteristics of the design itself. The content and depth of design principles vary, and the principles can be generic or content specific (Wang & Hannafin, 2005). They are produced for use in similar research and development in new settings (Amiel & Reeves, 2008; Design-Based Research Collective, 2003; Reeves et al., 2005; Wang & Hannafin, 2005). The principles assist in selecting and applying the most suitable knowledge for specific design and development tasks (Plomp, 2013; Reeves et al., 2005).

Previous research has highlighted a gap between game developers, learners, educators and curriculum designers and, thus, has encouraged the use of participatory methodologies for interdisciplinary game design (de Freitas, 2007; Winters & Mor, 2008; Wu et al., 2012) with an emphasis on end-users' involvement as partners throughout the game design process (Abras et al., 2004). According to de Freitas (2007), in this way, educators can be involved in the development of learning content into serious games. In addition, it is important to place learners at the centre of the design process in order to more closely address their needs (de Freitas & Jarvis, 2006). These considerations ensure that educators and learners can influence not only learning outcomes and content but also pedagogic design principles (de Freitas, 2007). When working with a participatory approach, the roles of designers and researchers are blurred, and the users become a critical component of the process (Sanders, 2002). For example, de Vito Dabbs et al. (2009) involved patient users in designing and testing health technologies for patients. The researchers found that involving patients helped to ensure the functionality and usability of the medium, increasing the likelihood of promoting intended health outcomes. A study by Thursky and Mahemoff (2007) of the development, through user-centred design, of a computerised decision support system to assist with prescriptions of antibiotics in an intensive care unit found that the user-centred design process facilitated physicians' and pharmacists' ownership of the system. This encouraged the immediate adoption and ongoing use of the system. Andrews et al. (2012) propose a collaborative prototype design process as a method for user-centred design as it emphasises collaboration, iterative testing and data-driven design. They used three design teams, each of which worked independently on similar tasks while designing a website. Each team profiled users, tested the usability of low-fidelity paper prototypes and created and tested the resulting wireframes. The findings were analysed collaboratively, and the data was used for the final prototype. The benefits of this were as follows: less money and time were required; the number of user comments and suggestions was greater than that of other systems; and more extensive usability testing of a greater number of design options was possible.

Design-based researchers draw from multiple disciplines (Sandoval & Bell, 2004). Winters and Mor (2008) state that an effective design process requires expertise from all relevant disciplines. Rizzo et al. (2011) argue that 'designing virtual patients that act as humans is a process that requires thorough understanding of the domain, the technology and how to apply the technology to the domain'. Game-based simulation is not effective per se; it must be significant in terms of learning, and it must combine a variety of technologies, pedagogical content and approaches. Pedagogically informed game patterns can be used as a practical tool to support collaboration among experts, such as experts in computer programming, pedagogy and the specific target domain (Bellotti et al., 2011).

Wu et al. (2012) conducted a meta-analysis of the learning theory foundations of game-based learning and investigated the issue from perspective of behaviourism, cognitivism, humanism and constructivism. Most of the articles that they reviewed in the meta-analysis failed to use a learning-theory foundation. However, Wu et al. (2012) have found that the experiential learning theory (Kolb, 1984) is the most frequently used learning-theory foundation for game-based learning. According to Kolb's (1984) theory, learning is a constantly evolving and deepening process in which knowledge is created through the transformation of experiences in a cycle of concrete experience, reflective observation, abstract conceptualisation and active experimentation. Game features integrated with instructional principles can help students to learn new concepts and develop mental resources for problem solving, facilitating the acquisition of procedural knowledge and a high level of cognitive processes (Cheng et al., 2014). de Freitas and Neumann (2009) present an exploratory learning model, which has its roots in Kolb's (1984) experiential learning cycle, and expand its practice into 3D immersive learning environments. The model consists of experience (abstract, lived or virtual), exploration (observation, activity, learning and interaction), reflection (meta-reflection) and forming abstract concepts and testing in different situations (abstract, lived or virtual). The model emphasises 'learning as an open-ended process that builds upon previous understanding, social interactions and practice- and problem-based approaches'.

When translating learning goals and practices into mechanical elements of game-play, both learning mechanics and game mechanics need to be considered (Arnab et al., 2015). According to Schell, (2014) game mechanics fall into six main categories: 1) space: various places that exist in the game and the spatial relationship between objects for example, how many dimensions a game has; 2) objects, attributes, and states: objects are anything that can be seen or manipulated, attributes are categories of information about objects, and state is the current value of an attribute; 3) actions: actions that the player can take, as well as strategies that emerge when the game is played; 4) rules: guidelines or laws that determine what actions the player can take; 5) skill: the physical, mental, or social skills of the player; and 6) chance: risk and randomness of the game that surprises and cause uncertainty to the player. These are simplified definitions of game mechanics, and they are described in detail in Schell (2014). Arnab et al. (2015), in turn, define learning mechanics, as 'dynamic operation[s] of learning, that we typically model relying on learning theories and pedagogical principles'. This definition highlights components such as specific objectives, tasks, activities and methods that construct a learning strategy, instructions or a process that is influenced by the context of learning. To produce an engaging gaming experience, a game has to immerse players in such a way that they totally concentrate on gaming, lose their sense of time and self-consciousness, experience a sense of purpose and curiosity and have a feeling of control (Kiili & Lainema, 2008). According to Bellotti et al. (2011), pedagogically informed game design patterns are concerned with content, not programming, and they include the following four patterns, which game designers should consider when designing games for educational purposes: integration patterns, cognition patterns, presentation patterns and engagement patterns. 'Integration patterns' are solutions that integrate game elements and learning objectives in pedagogically meaningful ways. 'Cognition patterns' are solutions that trigger reflective and metacognitive processes in players and stimulate players to process relevant content experienced through gameplay. Gameplay refers to the specific way in which players interact with a game. The goal of 'presentation patterns' is to enable players to effectively process the content. To prevent learners from missing relevant information during gaming, game designers should consider the cognitive price of every element and use visual effects to emphasise the crucial elements. Finally, 'engagement patterns' are solutions that motivate players to perform better in a game, that facilitate learning and that increase playing time and, thus, make the gaming experience meaningful.

For effective use of virtual worlds, the users' experience with the system and where it is used need to be taken into consideration (de Freitas et al., 2010). To produce an educationally efficient experience, learning objectives should not be discrete from gameplay (Kiili et al., 2012). Important factors to consider in designing virtual simulation applications are clinically reliable scenarios, and appropriate flow within scenarios (Botezatu et al., 2010). To enable the learning of clinical reasoning, the game has to enable the learner to assess a patient's condition, make clinical judgments about the patient's needs for nursing care, implement care decisions and procedures and reassess the effectiveness of the interventions (LeFlore et al., 2012), and thus, the game mechanics need to be built around the clinical reasoning process. Additionally, plenty of attention must be paid to creating realistic patient scenarios that emulate real-life cases as closely as possible (Forsberg et al., 2011; Guise et al., 2012). For example, in a study by Smith and Hamilton (2015), a virtual reality simulation of the insertion of a Foley catheter was developed based on current clinical guidelines, and this development incorporated various steps and techniques required for the proper insertion of a catheter. In simulation games, it is important that scenarios contain enough information to allow learners to reach a solution, and the case presentation has to be believable (Forsberg et al., 2011).

The graphics and technical aspects of the environment are created by designing virtual patient characters and constructing multimedia components (Guise et al., 2012; Rizzo et al., 2011). Virtual patient characters can represent people with a variety of appearances, ages and ethnic backgrounds. Scenarios can be enriched with various multimedia, such as still images, video, audio or website links (Guise et al., 2012). Development of patient scenarios and user interface is an iterative process in which testing and evaluation of case scenarios' content validity, internal consistency and authenticity are as important for overall tool development as testing and evaluating the technical platform (Guise et al., 2012, Honey et al., 2012). Improvements to the tool and scenarios are made based on the feedback received during the validity testing and evaluation (Guise et al., 2012).

2.4 Summarising the theoretical framework

The present study adopts the definition of 'clinical reasoning' as a logical, dynamic and ongoing process that includes six phases: collecting information, processing information, identifying problems and issues, establishing goals, taking actions and evaluating outcomes (Lewett-Jones et al., 2010; Simmons, 2010; Tanner, 2006). This definition was chosen because student nurses' thinking strategies are equivalent to those of novice nurses; they are task-oriented, action-oriented and rule-driven (Andersson et al., 2012; O'Neill et al., 2005). A systematic approach to following the phases and steps of the clinical reasoning process can help nursing students to learn clinical reasoning and, thus, to be more prepared for real patient situations. Furthermore, the phases of the clinical reasoning process are suitable for incorporation to the game mechanics.

Throughout this research, the term 'game-based simulation' will be used to refer to a learning method that combines game elements, simulations and learning objectives and focuses on game-based simulation delivered in web-based, mobile or virtual reality learning environments. For present purposes, the term 'simulation games' will be used to refer to artefacts (software) that replicate the decision making and processes of real-world situations. Further, the concept simulation games is disassembled into three components: game, simulation, and role. In this study, the elements considered to be important for learning clinical reasoning by playing games are the following: authentic representation of clinical practice; active participation in patient care; application of nursing knowledge; exploration; feedback; reflection; collaborative gaming; and usability.

A design-based research methodology is well suited to game design. It leads to the development of knowledge that advances theory and practice by using iterative cycles to design, test and evaluate the game in collaboration with researchers, educators, students and game designers (see Rizzo et al., 2011; Wang & Hannafin, 2005). The outcomes of design-based research are reusable design principles that are generated based on knowledge gained through the research process (Amiel & Reeves, 2008; Reeves et al., 2005; Reeves, 2006; Wang & Hannafin, 2005). These principles can help future developers to select the most suitable participants for specific design and development tasks (Plomp, 2013; Reeves et al., 2005). Design-based researchers draw from multiple disciplines

(Sandoval & Bell, 2004). A major advantage of design-based research is that it highlights the notion that the value of a theory depends on how it can improve practice (Design-Based Research Collective, 2003; Wang & Hannafin, 2005). Design-based research is conducted within a single real-life setting over an extended period of time (Sandoval & Bell, 2004; Wang & Hannafin, 2005). The theoretical framework is presented in Figure 1.

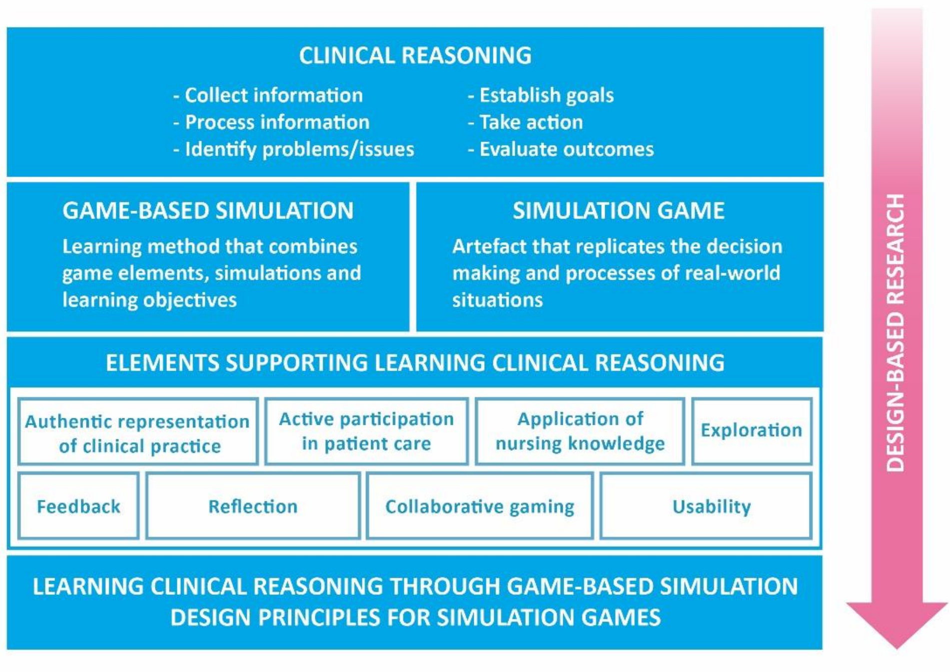

Figure 1. Theoretical framework of the study

3 Aims and research questions

This study aimed to obtain knowledge about learning clinical reasoning through game-based simulation; this knowledge can be used in developing and embedding new learning methods for clinical reasoning in nursing education. Clinical reasoning is an essential competency for professional nurses and is fundamental in recognising changes in patients' clinical conditions. However, research has shown that nursing students lack knowledge and skills in detecting and managing patient deterioration (Bogossian et al., 2014; Kajander-Unkuri et al., 2014a). For this reason, it is important to develop new learning methods that can be used in educating nursing students on recognising, monitoring and managing critically ill patients (see Soar, 2015). The literature has shown that game-based simulation is a potentially effective learning method for professional education (Cant & Cooper, 2014; de Freitas, 2007; Forsberg et al., 2011; Graafland et al., 2012; Petit dit Dariel et al., 2013). The purpose of this research was to generate design principles for simulation games that enhance learning and to design and develop a simulation game for learning clinical reasoning. Furthermore, to enable development of such a simulation game that enhances learning, the purpose was to investigate nursing students learning through gaming.

Research questions (RQs)

RQ 1 How does a simulation game support nursing students' experiential learning during gaming? (Article I)

RQ 2 How do nursing students learn clinical reasoning while playing a simulation game? (Article II)

RQ 3 Which elements in a simulation game explain and support learning clinical reasoning? (Articles I, III, IV)

RQ 4 What are the major iterative processes in design-based research when developing educational simulation games? (Articles I, III, IV)

4 Phases of the design-based research process

A design-based research methodology was used in this study since such designs encourage the development of knowledge that can advance pragmatic and theoretical aims (Wang & Hannafin, 2005). This study, and the idea of developing the simulation game, originated in a Healthcare and Nursing Learning Environment Development and Research Project (2011–2013). The simulation game was developed between 2012 and 2015. This dissertation exists independently of the wider project. The simulation game was developed specifically to meet the challenge of providing an engaging, motivating and safe learning environment for clinical nursing.

Designing a simulation game for nursing education requires knowledge of nursing, learning theories, game design, user interface development, game programming and computer graphics and animation. In this study, the game was designed in collaboration with researchers, nurse educators, students, programmers, 3D artist and interface designers. The idea of developing a simulation game for learning clinical reasoning grew from my understanding of the benefits of simulation and game-based learning for professional education. My role as an educator and researcher during the design process was to share knowledge of nursing, clinical reasoning, pedagogy and research. Design-based research uses mixed research methods to maximise the credibility of the findings (Wang & Hannafin, 2005); in the present study, qualitative and quantitative methods were used to produce new knowledge on learning clinical reasoning through game-based simulation. This knowledge was used in the generation of design principles for simulation games. According to Wang and Hannafin (2005), the value of theoretical knowledge depends on how it can improve practice. The knowledge gained through the design process in this study can be used to develop and embed new learning methods for clinical reasoning in nursing education.

Design-based research consists of iterative cycles of design, implementation, analysis and redesign, and the iterations improve on the initial design (Wang & Hannafin, 2005). This research consists of six phases, which are (1) defining design principles for the simulation game design; (2) developing the simulation game; (3) first cycle of testing and refinement of the simulation game in practice; (4) reflection to produce new design principles for enhancing the simulation game; (5) second cycle of testing and refinement of the simulation game in practice; and (6) generating design principles for the simulation game (see Amiel & Reeves, 2008; Reeves, 2006) (Figure 2).

I played several roles in this design-based research process: nurse, nurse educator, game designer and developer and educational design researcher. I began my research during the Health Care and Nursing Learning Environment Development and Research Project (2011–2013) at the Helsinki Metropolia University of Applied Sciences. In simulation games, I saw an opportunity for students to learn to recognise signs of deterioration in an immersive virtual environment where they can practice their skills without the possibility of harming real patients. I realised that the clinical reasoning process could be learned by combining simulations and game elements, thus empowering the learners in their clinical reasoning ability and allowing them to develop their ability to detect signs of deterioration in hospitalised patients. Such a learning environment did not yet exist, so it would have to be developed. My role as a nurse and nurse educator included knowing the intended users (students and nurse educators); as a game designer and developer, and educational design researcher, my role was to translate that knowledge into design principles through the design-based research process. I have also been responsible for overseeing the research process as a whole.

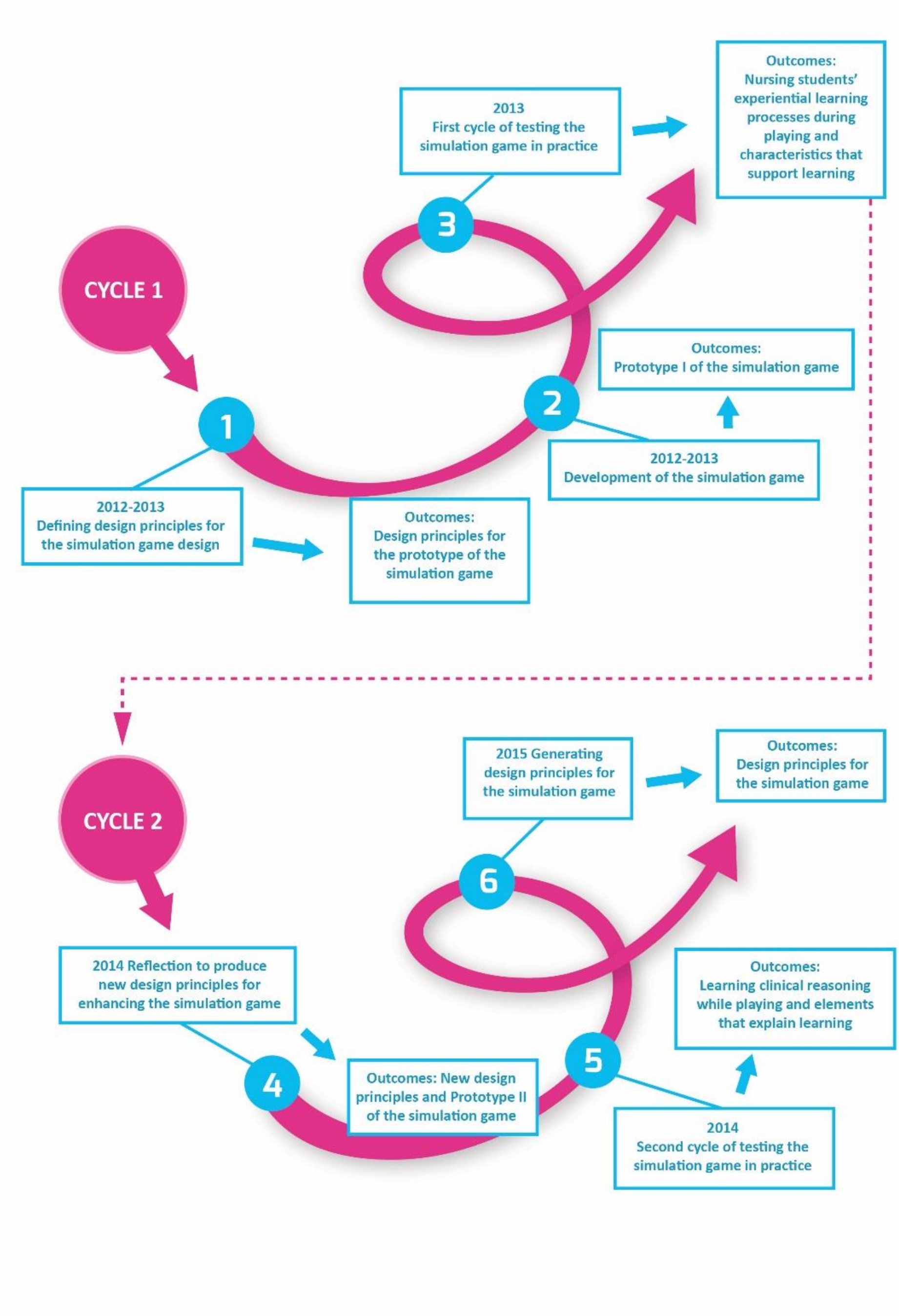

Figure 2. Phases and outcomes of the design-based research process

4.1 Design principles for the simulation game design

The simulation game development project was conceived in response to the need to design and develop new learning environments to improve nursing students' skills in detecting signs of deterioration in hospitalised patients (see Ludikhuize et al., 2012; Soar et al., 2015) and, thus, to develop their clinical reasoning during education (Forsberg et al., 2011; Kajander-Unkuri et al., 2013; Lewett-Jones et al., 2010; Petit dit Dariel et al., 2013). Simulation had shown its educational value as a learning method for clinical reasoning (Forneris et al., 2015; Jensen, 2013; Lapkin et al., 2010, Lapkin & Lewett-Jones, 2011; Pottier et al., 2013; Young and Jung, 2015). In addition, the literature had shown positive indications that playing serious games could be an effective learning method (Cant & Cooper, 2014; de Freitas, 2007; Forsberg et al., 2011; Graafland et al., 2012; Petit dit Dariel et al., 2013) in that such games offer engaging and immersive learning experiences for students.

The game design process started with a search and review of the relevant literature on game design in order to gain insight into the existing knowledge on virtual learning environments, virtual simulations, virtual scenario-based learning solutions and games used in healthcare education. Existing applications focusing on healthcare education were also sought, especially from Nordic countries, Baltic countries, Russia, and the USA (see Appendix 1). One similar virtual simulation for the purpose of medical education was found in Finland, but it was not available for further development in the context of nursing education. On an international level, several virtual simulation-based applications for healthcare education existed (The final report: educational games, 2014). Many of these had been developed in universities or hospitals according to local clinical protocols and, as such, they were not directly applicable to a Finnish context because protocols vary from country to country.

At this point, it appeared that combining the elements of simulation and gaming in the simulation game design could offer compelling learning experiences for future users. The design principles were generated based on theoretical knowledge. The learning content of the simulation game is clinical reasoning, and thus, the game mechanics were built around the clinical reasoning process (Lewett-Jones et al., 2010; Simmons, 2010; Tanner, 2006). Here, the elements of simulation referred to the replication of real-life clinical situations in which learners would take the role of a nurse. The research evidence (see Table 1) highlighted the importance of realistic and authentic patient scenarios in order to produce expected learning outcomes. The game elements at this point consisted of an immersive 3D environment and real-time feedback. An additional goal was that the simulation game would be easy to use (Table 1). (RQs 1 and 4; Articles I and IV)

As a result of this phase, the design principles for the simulation game were defined in co-operation with the development team. As the team's nurse educator, I was responsible for the subject domain and pedagogy. Besides me, the team consisted of the project manager of the Health Care and Nursing Learning Environment Development and Research Project (2011–2013), who possessed expertise in simulation games, and a software architect. The design principles for Prototype I of the simulation game are presented in Table 1 (modified from Table 1, Article I).

Table 1. Design principles for the simulation game prototype in the first design and development cycle

Design principle	Reference
Apply clinical reasoning process	Cook et al. (2010); Forsberg et al. (2011); Hart et al. (2014); LeFlore et al. (2012); Lewett-Jones et al. (2010); Petit dit Dariel et al. (2013); Tanner (2006)
Create realistic and authentic patient scenarios	Cook et al. (2010); de Freitas (2007); Forsberg et al. (2011); Guise et al. (2012); Honey et al. (2012); Heinrichs et al. (2010); Huwendiek et al. (2009); Jeffries (2007); LeFlore et al. (2012); Rizzo et al. (2011)
Use immersive 3D environment	de Freitas (2007); Heinrichs et al. (2010); Huwendiek et al. (2009); Miller & Jensen (2014)
Provide real-time feedback	Cook et al. (2010); de Freitas (2007); LeFlore et al. (2012)
Create easy-to-use interface	Forsberg et al. (2011); Heinrichs et al. (2010); Hurst et al. (2011); Kidd et al. (2012); Zhua et al. (2012)

4.2 Development of the simulation game

The simulation game was developed by the software architect based on the design principles that had been defined in the study's previous phase (see Table 1). At the end of 2012, the first version of Prototype I was made. The Unity development platform was used to create the game. Unity was chosen for its fast prototyping capabilities. With Unity's WebGL build option, the game is compiled as HTML5/Javascript. This enables the game to be played using modern web browsers in Windows, Mac, and Linux environments. The game requires an internet connection in order to download scenarios and upload scores to the cloud. Minimum requirements for the game are a modern office computer (i3 2100, 4GB RAM), a 10mb/s Internet connection, and a modern web browser (Google Chrome, Mozilla Firefox, or Microsoft Edge). In spring 2013, the game was developed further, and the first testing session for teachers and students was organised. In these sessions, the game was presented, but participants could not play it. However, they were able to comment on the game and make suggestions for how to develop it further. A playable version of Prototype I was ready in September 2013. (RQ 4; Article IV)

In Prototype I, the gameplay was linear, and the player controlled a nurse avatar from a bird's-eye view (Figure 3). The game simulated real-life clinical situations and patients' clinical conditions. In the game, the player acted in the role of a nurse. The game consisted of patient scenarios, which are events designed around a specific clinical situation requiring clinical reasoning. During gameplay, learners developed their clinical reasoning skills using different clinical situations and patient scenarios. The game was designed to guide learners through the clinical reasoning process of collecting and processing information, identifying problems and issues, establishing goals, taking action and evaluating outcomes. The goal in the game was to find out what was wrong with the patient and make the patient feel better. The challenge was to find relevant information related to the patient's clinical condition and to choose the correct nursing intervention. The learning objectives in the scenarios included assessing patients' clinical status using the ABCDE approach (which includes vital signs), recognising changes in a patient's condition and patient deterioration and implementing nursing interventions. According to Thim et al. (2012), 'The Airway, Breathing, Circulation, Disability, Exposure (ABCDE) approach is a systematic approach to the immediate assessment and treatment of critically ill or injured patients'. It can be applied in all clinical emergencies for all patients since the clinical signs of critical conditions are similar regardless of the underlying cause. The ABCDE approach can improve the performance of treatment teams, and it is recommended that this approach always be used when critical illness or injury are suspected. In the game, students collect information by asking questions from the patient and by assessing vital signs. Based on this assessment, they make decisions about interventions and implement them. At the end of the game, students receive feedback on their performance. (RQs 1–4; Articles I–IV) The game has an integrated editor through which educators can create their own patient scenarios for use in the game. Botezatu et al. (2010) argue that, to achieve realism and content validity in such applications, localisation of the scenarios is necessary. Users find virtual simulations to be more authentic and engaging when local conditions are taken into consideration (Wilson, 2012).

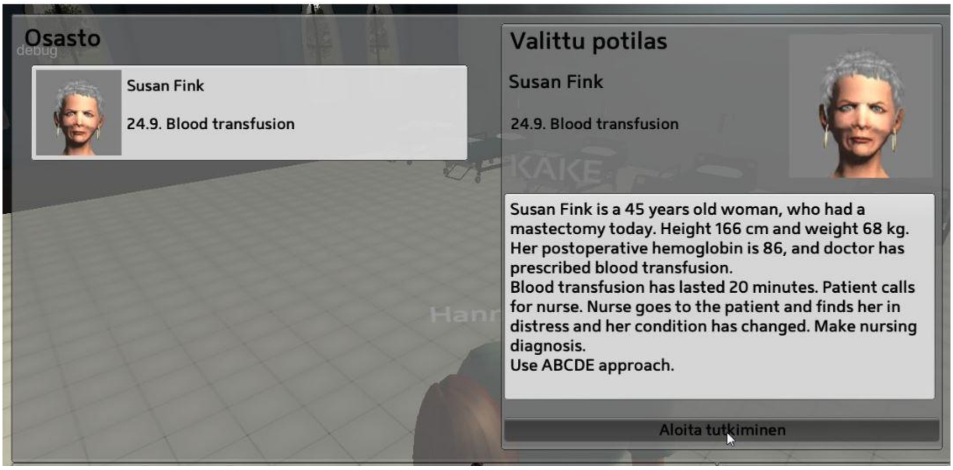

Figure 3. Screenshot of Prototype I (2013)

4.3 First cycle of testing and refinement of the simulation game in practice

In the third phase of the study (RQs 1 and 4; Articles I and IV), experiential learning processes were considered to be an important component of professional learning in nursing education. The purpose of the study was to investigate nursing students' experiential learning processes during a 3D simulation game and to determine which game characteristics supported experiential learning (RQ 1; Article I).

4.3.1 Participants

In this phase (RQ 1; Article I), purposive sampling (see Burns & Grove, 2005) of undergraduate nursing students was used. Purposive sampling refers to a sampling technique in which members of a population are chosen to participate in a study based on the researcher's own judgment of the sample's representativeness. The invited participants were from a group of nursing students who were starting their bachelor's theses; eight of these volunteered to participate to the study. The participants were third-year nursing students, five male and three female, aged 21–32. They had all been in practical training in different clinical settings, including elderly care, acute nursing in medical and surgical wards and nursing of clients with mental or substance abuse problems. One participant had experience in nursing of children and young persons. Participants had three months to three years of work experience in the health services; most had less than a year. They all had experience in using technology in general, in their studies and in nursing care. One participant did not play leisure games at all, two played daily, two played weekly and three played monthly. None of the participants played educational games.

4.3.2 Data collection

The data were collected during four gaming sessions in autumn 2013 at the University of Applied Sciences in Helsinki. Eight nursing students participated in these sessions. The gaming sessions were held in a computer classroom modified with research equipment for video and audio recording. Participants were assigned to two groups of four participants each. All participated in two gaming sessions, the first in September and the second in December. During the sessions, they participated in one or two single-player and multiplayer patient scenarios. In the first session, there were four students in each group, and in the second session, there were three students in each group (two dropped out for personal reasons). (Article I)

Data consisted of audio and video recordings of gaming sessions and focus group interviews (Article I). Video is a useful method when conducting research in that it allows close examination of teaching and learning in learning environments (Derry et al., 2010). Video recordings were selected since it enable analysis of participants' practices and the knowledge, reasoning and procedures on which they rely to accomplish their activities (Heath et al., 2011). Thus, these recordings contribute significantly to understanding learning processes and to improving the design of new learning environments by offering opportunities for close documentation and observation (Derry et al., 2010). Video data was collected twice, and in the intervening period, some changes were made to the game. The cameras were set in fixed positions for close-up shooting; no panning or zooming were used (see Derry et al., 2010). The cameras were placed in front of the participants, allowing the researcher to see their faces, their hands on the computer mouse and a close-up view of the computer screen. The microphone recorded their speech during play. Gaming and the game prototype acted as thought instigators, and participants were asked to comment on the game while gaming. The information obtained through their comments was used to redesign the game. The timeframe for solving a scenario was 10 to 20 minutes. The researcher was present during all gaming sessions, facilitating and observing. (Article I)

Focus group interviews involved semi-structured discussions with students. This method was chosen because group dynamics can assist students in expressing and clarifying their perspectives (Burns & Grove, 2005). Interviews were conducted in two groups, immediately after the first gaming sessions, with four participants in each group. Participants were asked to describe how they learned during the simulation game and what game characteristics supported their learning. They were also asked to describe what characteristics would influence their learning if they were absent from the game. The duration of the focus group interviews ranged from 45 minutes to 1 hour and 20 minutes, and they were audiotaped. (Article I)

4.3.3 Data analysis

The data were investigated using thematic analysis (Braun & Clarke, 2006). They were saved using the Atlas.ti software. One researcher conducted the analysis, which included four phases. First, the researcher familiarised herself with audio and video data from the gaming sessions and focus group interviews. The videos were watched in order to identify episodes for further detailed analysis (Derry et al., 2010). Further, all speech was transcribed, and this material as a whole was analysed inductively. Notes were made about ideas for coding. The researcher searched for meanings and patterns in how students learned during the simulation and what game characteristics supported their learning. Speech was coded, codes were grouped into subthemes and subthemes were grouped into themes (see Article I, Table 2) (Braun & Clarke, 2006). After the themes were identified, they were organised, using Kolb's (1984) theory as a framework to describe the experiential learning process. (Article I)

4.3.4 Outcomes: Nursing students' experiential learning processes during gaming and characteristics that support learning

Regarding RQ 1, the findings showed that Kolb's experiential learning cycle can usefully be applied to nursing students' experiential learning processes during simulation games. The result of the first cycle of testing and refinement of the simulation game in practice established that nursing students focused strongly on the patient during gaming. Students' concrete experiences in the simulation game were supported by audio-visual authenticity, authenticity of patient scenarios and interactivity. Students reflected on their patient-related experiences, and the data suggested that feedback triggered reflection. The results revealed that students conceptualise by applying nursing theory during gaming and, thus, internalising procedures. During gaming, they experiment actively by exploring and making decisions. (Article I)

For learning to occur, the game needed to create an experience of real patient care (see Article I, Table 3). Authenticity of patient scenarios required realistic and challenging clinical conditions and patients who varied in age and sex. Students expressed that it would be important that a patient's clinical condition were visible. This would be achieved by audio-visual authenticity, which students referred to as 'game graphics', 'animation' and 'sounds'. They referred to patients' appearance and medical devices in terms of 'graphics'. With the help of the game's animation, students noted that a patient's clinical condition and any changes in it could be observed. The animation included patient movements, facial expressions and gestures. Sounds referred to both the noises of the hospital and the noises caused by patients, including their voices. Students felt that sounds suggesting clinical conditions could direct them to the patient's problem. Audio-visual authenticity could enable the students to observe and notice patients' problems and changes in their clinical conditions. Regarding interactivity, students referred to the player's potential scope of reactions to patients' care needs and how the patients reacted to the care that they were given. (Article I)

During gaming, students reflected on their patient-related experiences, the knowledge that they had gained and their performance during gaming (see Article I, Table 4). The data suggest that feedback triggered reflection. As well as favouring immediate feedback on their performance, students wanted the game to keep score; they stated that an accumulating score would increase their satisfaction. They felt that the best feedback during gameplay would be a change in the patient's clinical condition. If the effects of their actions on the patient's clinical condition were not visible, the consequences of those actions would remain unclear. Feedback after gameplay included the player's total score, provision of reasoning and a description of the correct treatment for the patient in question. The provision of reasoning for correct choices would help students to reflect both on decisions made and on the underlying knowledge gained. Students described how a change in a patient's condition as a result of the player's actions would be, in itself, immediate feedback. Feedback at the end of the game helped the players to consider their actions and to learn from them. (Article I)

'Application of nursing theory' refers to students' application of previously acquired knowledge in resolving patient scenarios (see Article I, Table 5). Students described the importance of having opportunities to apply their theoretical knowledge in practice before caring for real patients. In the simulation game, students encountered situations that they had not experienced before, and in this way, the game could teach procedures to be applied to new situations. Also, the game could be repeated, which helped players to internalise and automatise procedures so that they could perform them correctly in a real nursing situation. The students also suggested that gaming supports independent learning because it can be done while they have free time and motivation. 'Internalising procedures' means learning various procedures (such as clinical protocols) well enough to apply then in real-life patient situations. Students were also able to learn prioritisation through the game. (Article I)

The results indicated that students experiment by exploring and making decisions (see Article I, Table 6). 'Exploration' refers to taking actions, making mistakes and learning from those mistakes. The game provided a safe environment in which to make mistakes because real patients would not come to harm. 'Repetition' refers to students playing the game repeatedly and, thus, improving their readiness to act in working life. 'Decision making' refers to how students considered their choices in relation to the patient's clinical condition. The advantage of this independent decision making was that students had to make decisions based on their own knowledge, and then, they received feedback regarding their decisions. This helped them to realise the consequences of their actions. Students stated that the game supported learning in combination with other teaching methods in which the student could be an active agent. Collective decision making was advantageous in that it was possible to discuss options with other students, and support was available for decision making. (Article I)

Regarding characteristics that supported experiential learning during gaming, the results revealed that Prototype I lacked sufficient realism (Article I). Students stated that the patient scenarios in the prototype were authentic but that the audio-visual authenticity and interactivity were not well realised. Thus, the experience of real patient care was absent, and students were not immersed in the game. However, the application of nursing knowledge and exploration were well realised. Prototype I did not provide immediate feedback during the game, and participants stated that they wanted it to do so. Changes in the patient's clinical condition, which participants considered to be the best possible feedback during gaming, did not occur in play with Prototype I. Feedback after gameplay, however, was better realised than immediate feedback. (Article I)

In Prototype I, the user interface was confusing, and as a result, players did not know what to do while playing the game. The linear gameplay prohibited the players from proceeding efficiently with patient care. For example, if the patient had trouble with breathing, the player could not provide the patient with oxygen until the player assessed all other vital signs. This did not replicate real life, in which nursing interventions are prioritised based on patients' needs. The game had also several technical problems. These caused frustration and anxiety in players, which diminished their engagement and may have influenced learning outcomes. (Article IV)

The results reinforced and validated the original design principles (see Table 1). The major finding was that the application of familiar characteristics of leisure games, such as interactive 3D environments, high-quality animations, graphics and sounds, and immediate feedback needed to be better integrated into the simulation game (Articles I and IV). This finding directed me to the literature on game-based learning, serious games and game design literature. Altogether, the results of this round of testing had a significant impact on the simulation game design in that they emphasised the importance of integrating game elements and virtual simulation.

4.4 New design principles for enhancing the simulation game

The original design principles (Table 1) were complemented with new principles (Table 2), which were generated based on the empirical knowledge gained through testing (RQ 4; Articles I and IV). Using game elements such as visual appearance, interactivity, immersion and feedback in virtual simulations can enhance learning of clinical reasoning. To create a feeling of genuine concern for the patients' clinical condition and increase the willingness of the players to help the patients, improvements were made to the visual appearance of the game as well as to the interaction between the player and the game environment. At this point, the project began to apply the principles of game design and the development team was widened to include game designers: a programmer who had experience in game development, an interface designers and a 3D artist. (Article IV) During this phase, nursing students who participated in the first design cycle (see Article I) collaborated with the development team in workshops. They had gained valuable experience from testing Prototype I and offered perspectives about what elements in the simulation game could support their learning. They made a remarkable contribution to the new design principles. The development team designed Prototype II from scratch (Figure 4). (Article IV)

Table 2. Renewed design principles for the simulation game prototype in the second design and development cycle

Design principle
• Integrate clinical reasoning process to game mechanics: allow players to move forwards and backward between interview, assessment and implementation sections based on the patient's clinical condition (non-linear gameplay).
• Use authentic graphics, animations and sounds that replicates real clinical situation, patient, hospital environment, and sounds.
• Allow players to interact with the patient and the hospital environment.
• Provide immediate feedback on performance in forms of right/wrong, scoring, in-game facilitator's comments, and change in patient's clinical condition. • Provide feedback after completed scenario in forms of total score, reasoning, and description of correct performance.
• Create intuitive and approachable user interface.

'Visual appearance' refers to the game's authenticity in terms of graphics, animation and style (Articles I and IV). Squire (2006) noted that players need to learn to read the signs of the game system in order to act in the game world. In other words, graphics are more than pictures; they are signs that the player must learn to read. 'Interactivity' refers to the interaction (i.e. the action-reaction cycle) between the player and the game. Player-game interaction refers to the information exchange between the player and the game (Ang et al., 2008). By participating actively, students become engaged with the patient and the situation (Guise et al., 2012; Heinrichs et al., 2012). Through interactions with the virtual patient and environment, the learner will begin to systematically apply the clinical reasoning model (Petit dit Dariel et al., 2013). 'Immersion' refers to the player's experience of being drawn into the game so that they have the feeling or perception of being part of the game environment. Interactivity supports immersion, which can be undermined by a lack of authenticity (Article IV). If patients are not lifelike and learners cannot interact with them, they are likely to become frustrated and bored (Carlson-Sabelli et al., 2011).

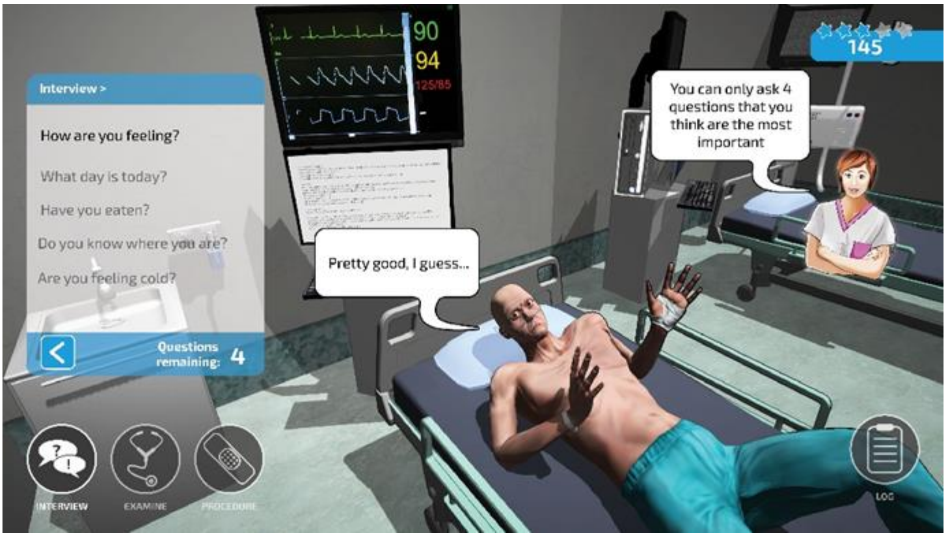

Figure 4. Screenshot of Prototype II (2014)

In Prototype II, interactive elements included students' reactions to the patients' clinical conditions and patients' reactions to care received. Immersion was enhanced by changing the game view from a bird's-eye view to a first-person view. The game view changed to include a 3D character (the patient) with authentic reactions in a 3D environment (representing the hospital ward) with authentic equipment. The interface was also changed, starting with a step-by-step modelling of the clinical reasoning process. The game mechanics had been originally built around the clinical reasoning process, but now, the gameplay was non-linear, allowing the player to proceed in patient care based on the patients' clinical condition (i.e. the player could move forwards and backward between the interview, assessment and implementation sections). (Articles II and IV)

A great effort was made to develop the feedback systems of the game, and in this phase, the game provided immediate, sustained and cumulative feedback (see Rigby & Ryan, 2011) in the form of points, patient reactions, in-game facilitator's comments and effects of success and failure (Articles II and IV). Hospital sounds and patients' voices and noises were considered important for learning, but the development of sound was left out for financial reasons (Article IV). The learning and game mechanics applied in Prototype II are presented in Table 3. They were formulated by applying the learning mechanics–game mechanics map created by Arnab et al. (2015; see also Article III, Table 1).

Table 3. Learning and game mechanics in the simulation game prototype

Learning mechanics	Game mechanics
Simulation	Realism
Instructional	Role play
Guidance	Simulate/Response
Observation	Cut scenes/Story
Participation	Strategy/Planning
Question & Answer	Question & Answer
Identify	Levels
Plan	Time pressure
Experimentation	Meta-game
Action/Task	Rewards/Penalties
Assessment	Assessment
Feedback	Feedback
Reflect	Action points
Analyse	
Repetition	
Responsibility	

4.5 Second cycle of testing and refinement of the simulation game in practice

The fifth phase of the study had three purposes. The first purpose was to investigate nursing students' experiences of learning the clinical reasoning process by playing a 3D simulation game (RQ 2; Article II). Learning the clinical reasoning process consists of phases described by Lewett-Jones et al. (2010): collect cues and information, process the information, identify problems and issues, establish goals, take action and evaluate outcomes (Article II). The second purpose of this phase was to describe and explain how nursing students can learn clinical reasoning by playing a simulation game (RQ 3; Article III). Based on the theoretical framework and outcomes of the previous phases of the study, the elements considered important for learning clinical reasoning by playing games were as follows: authentic patient-related experiences; active participation in patient care; application of nursing knowledge; exploration; feedback; reflection; collaborative gaming; and usability (see Article III, Figure 1). The final purpose of this phase was to generate principles for the design of educational simulation games (Article IV). Data was collected from nursing students using a questionnaire (Articles II and III) and from both nursing students and nurses using observation and focus group interviews during user testing (Article IV). User testing was conducted to ensure that Prototype II enabled learning.

4.5.1 Participants

Purposive sampling was used to enable selection of certain subjects or events for inclusion in the study (Burns & Grove, 2005). In total, 166 undergraduate nursing students from the autumn 2014 surgical nursing course participated. The surgical nursing course is mandatory for nursing students and is placed in the second or third semester in nursing curricula. More than half (54.8%) of the participants were in the 21–25 age group. A majority (87.3%) of participants had upper secondary education in the form of matricular examination or vocational upper secondary education. Twenty-one participants had received higher education. The majority of participants were in their second year of study. Sixty percent of the participants had less than one year of work experience in the social and health services. A total of 63.2% played digital games occasionally—that is, weekly, about once a month or even less often (Article II, Table 1). (Articles II and III)

In addition, 60 neurosurgical intensive care unit nurses from University Central Hospital in Helsinki participated in user testing (Article IV). The nurses' contribution to the game design was valuable since they understand the complexity of clinical reasoning in a real-life setting. Participating nurses played the neurosurgical patient scenario, which was created by a clinical nurse specialist and a registered nurse in collaboration with the game development team.

4.5.2 Data collection

During this phase, two types of data were collected: quantitative data, which was collected using a questionnaire, and qualitative data, which was collected using observations of gaming, field notes and focus group interviews. An online questionnaire was selected because it enabled us to collect large amounts of information from the students immediately after they played the game. The disadvantages of using a questionnaire are that the questions have less depth than interview questions and that subjects are unable to go into detail or ask for clarification of the questions (Burns & Grove, 2005). Additionally, the length of the questionnaire may reduce the participants' willingness to complete it. The quantitative data were collected from nursing students during 13 gaming sessions in autumn 2014 at two of Finland’s largest universities of applied sciences. The gaming session was one of the course’s pedagogical solutions and was held in a classroom with computers (Figure 5). Participating students played a Finnish version of the game involving two to five postoperative patient scenarios. The learning objectives in the postoperative scenarios included assessing a patient’s clinical status using the ABCDE approach, recognising changes in a patient’s condition and patient deterioration and implementing nursing interventions. While some participants played each scenario only once, most played them at least twice. The gaming sessions were 30–40 minutes long. After playing, all participants were asked to complete an online questionnaire. (Articles II and III)

Figure 5. Gaming session in a university of applied sciences in October 2014

As no instrument that measures learning of clinical reasoning through a simulation game was available, an instrument was developed specifically for this project. Its development was based on the existing literature of clinical reasoning (Lewett-Jones et al., 2010; Simmons, 2010; Tanner, 2006) and on elements considered to be important for learning clinical reasoning by playing games (Blakely et al., 2009; Dev et al., 2011; Erhel & Jamet, 2013; Forsberg et al., 2011; Heinrich et al., 2008, 2012; Ketamo & Suominen, 2010; Kiili et al., 2012; LeFlore et al., 2012; McCallum et al., 2011; Roh et al., 2013; Rizzo et al., 2011; Tsai et al., 2015; Wilson, 2012; Zary et al., 2006). The design principles generated thus far (Tables 1 and 2) were also applied in developing the instrument. The instrument was pilot-tested with five nursing students. Two senior lecturers holding doctoral degrees in nursing science, one senior lecturer with experience in using games in nursing education and a professor of multimedia evaluated the instrument to ensure its content and construct validity. Some changes were made to variables, measurement scales and instructions to respondents.

The questionnaire included five demographic items: age, educational background, study phase, work experience in social and health services and gaming activity. First (RQ 2; Article II), learning clinical reasoning process by playing was measured. The questionnaire consisted of six subscales and 14 items, each of which was rated using a five-point Likert scale. A score of 5 indicated a response of 'very much' while a 1 indicated 'not at all'. The subscales are presented in table 4. Second (RQ 3; Article III), nursing students' experiences of the game and learning when playing a simulation game as well as elements explaining learning were measured. Questionnaire consisted of nine subscales and 41 items. A four-point Likert scale ('4' means 'definitely agree', '1' means 'definitely disagree') was used for these subscales. The subscales are presented in table 4.

Table 4. Subscales and items of the instrument

Subscales and items of the instrument in Article II (RQ 2)	
1. Learned to collect information 1.1 Learned to collect information by interviewing patient 1.2 Learned to collect information by observing patient 1.3 Learned to collect information from measurable patient data	**2.** Learned to process information 2.1 Learned to analyse data to reach an understanding of signs or symptoms 2.2 Learned to distinguish relevant from irrelevant information
3. Learned to identify problems/issues 3.1 Learned to make nursing diagnosis 3.2 Learned to make decisions on patient care independently 3.3 Learned to make decisions on patient care in cooperation with other students 3.4 Learned to make decisions on patient care promptly	**4.** Learned to establish goals 4.1 Learned to prioritise patient's need for care 4.2 Learned to set goals 4.3 Learned to plan nursing interventions
5. Learned to take action 5.1 Learned to implement nursing interventions according to symptoms	**6.** Learned to evaluate outcomes 6.1 Learned to evaluate effectiveness of interventions

Subscales and items of the instrument in Article III (RQ 3)	
1. Learning clinical reasoning through gaming 1.1 Learned to collect information 1.2 Learned to process information 1.3 Learned to identify problems/issues 1.4 Learned to establish goals 1.5 Learned to take action 1.6 Learned to evaluate outcomes	**2.** Authentic patient-related experiences 2.1 Patient scenarios were realistic 2.2 Patient scenarios had enough information 2.3 Patient scenarios were sufficiently challenging 2.4 Patient care felt real 2.5 Patient interaction felt real
3. Active participation in patient care 3.1 I participated actively in patient care	**4.** Application of nursing knowledge 4.1 Game combines theory and practice 4.2 I applied theoretical knowledge while playing 4.3 I applied my previous experience of patient care while playing
5. Exploration 5.1 I tested my competence in the game 5.2 I learned by trial and error in the game 5.3 I can make mistakes safely in the game 5.4 I learned by tryouts in the game	**6.** Feedback 6.1 I received immediate feedback on my decisions 6.2 My mistakes were corrected during gameplay 6.3 I received continuous feedback on my performance 6.4 I received feedback after a completed scenario 6.5 I could follow my progress in the game 6.6 If I received immediate feedback it made me consider my decisions 6.7 If I received continuous feedback I could follow my competency development 6.8 If I received feedback after a completed scenario it revealed my competence
7. Reflection 7.1 I considered different options in the game 7.2 The game made me consider my decisions 7.3 While playing I considered my own experiences in patient care 7.4 While playing I considered decisions together with other students 7.5 My professionalism evolved by gaming	**8.** Collaborative gaming 8.1 Collaborative gaming was fun 8.2 I learned from my fellow students by collaborative learning

9.	Usability
9.1	The game is suitable for social services and health care studies
9.2	Studying by playing was fun
9.3	The game is useful for learning clinical reasoning
9.4	Playing increased my interest in learning clinical reasoning
9.5	The game was easy to use
9.6	I knew how to play the game
9.7	The game motivated me to study

The qualitative data were collected from nursing students and nurses in autumn 2014. In total, 60 nurses and 166 nursing students participated in the user testing. During this phase, the data consisted of observations of gaming, field notes and focus group interviews collected during user testing in gaming sessions (Article IV). The methods were selected because they enabled assessment of the product's ease of use and of how successfully the product fulfilled its intended purposes (Milton & Rodgers, 2013). Testing the simulation game over a period of time with end-users is a vital stage in developing a product, helping to avoid expensive mistakes and delays (see Milton & Rodgers, 2013). Design-based research is conducted in a real-life environment; this is unlike user trials, in which users test products under controlled conditions. In user testing, the product is evaluated by being tested on its intended user group (see e.g. Verkuyl et al., 2016). Researchers were present in the classroom, observing the gaming, making notes (without attempting to anticipate events) and remaining unobtrusive (Heath et al., 2011; Milton & Rodgers, 2013). Participants were able to ask questions from the researchers. For example, if they were stuck at some point in the game and did not know how to proceed, the researchers could help. The researchers observed and made notes of the click path and its ease of use. Researchers also observed players' visible reactions. According to Milton and Rodgers (2013), by observing the user's behaviour, emotions and difficulties, designers are able to identify development needs and qualities that require improvement. All of the nurses and 60 nursing students participated in the focus group interviews. The interviews were conducted in groups of five to eight participants. Questions were asked, but the conversations were not restricted to the questions. The interviews were audio recorded.

4.5.3 Data analysis

Quantitative data analyses were performed using the statistical programme SPSS 22.0 (Articles II and III). In accordance with the purpose of investigating nursing students' experiences of learning the clinical reasoning process by playing a 3D simulation game (RQ2; Article II), the researchers used descriptive statistics, independent sample t-tests, one-way analyses of variance (ANOVA; post hoc comparisons were made using Tukey's HSD test or Tamhane's test), cross tabulation and chi-square tests and multifactor analyses (logistic regression, ordinal logistic regression and multifactor analysis of variance) (Article II). Further, in accordance with the purpose of describing and explaining how nursing students learn clinical reasoning by playing a simulation game (RQ3; Article III), the researchers used descriptive statistics, Pearson correlation coefficients and a stepwise linear regression model (Article III).

Two researchers conducted the analysis of the qualitative data from user testing. The data were analysed inductively. First, one researcher listened to audio data from the focus group interviews, writing down relevant comments regarding game development. After that, the answers to the questions where researched, transcribed and categorised into themes. The notes from the gaming observations were used as complementary material for the focus group interviews. At this point, the other researcher read the transcriptions within the themes and reflected on and wrote down the outcomes in relation to the design principles generated during earlier phases of the study (see Tables 1 and 2). (Article IV)

4.5.4 Outcomes: Learning clinical reasoning by playing and elements that explain and support learning clinical reasoning

Learning clinical reasoning by playing a simulation game

In this section, RQ 2 will be answered. According to the findings, a majority of students felt that they learned the phases of clinical reasoning quite or moderately well during the gaming (Article II, Table 2). Thus, such games can be beneficial for learning clinical reasoning. During play, students reported learning the most about taking action and collecting information and the least about establishing goals for patient care and evaluating the effectiveness of interventions. They also reported learning the most when collecting information by interviewing patients and implementing nursing interventions according to symptoms; they learned the least when evaluating the effectiveness of interventions. Learning about the different phases of the clinical reasoning process showed strong positive correlations (see Article II, Table 3). Dependence was statistically significant. The strongest correlation was between learning to identify problems and issues and learning to establish goals (Pearson $r = 0.79$). Identifying problems and issues showed a strong correlation with all phases (see Article II, Table 3).

Age, educational background, study phase and work experience were not significantly associated with learning the clinical reasoning process (Article II); neither was gaming activity in non-digital and educational games. However, the difference between those who played digital games actively and those who played only occasionally or not at all was statistically significant (see Article II, Table 6). The results showed that those who played digital games daily or occasionally felt that they learned more about clinical reasoning by playing the game than those who did not play digital games felt they had learned (see Article II, Table 6).

Elements that explain and support learning clinical reasoning

The results corresponding to RQ 3 showed that nursing students rated highly both the simulation game and the degree to which they learned when playing (see Table 3). The findings showed that usability, application of nursing knowledge and exploration have the most impact on learning clinical reasoning when playing simulation games (see Article III, Table 4). The findings also revealed that authentic patient-related experiences, feedback and reflection have an indirect effect on learning clinical reasoning. The elements of learning clinical reasoning through playing a simulation game showed strong positive correlations with each other (see Article III, Table 3). Dependence between the elements was statistically significant. The strongest correlation was between application of nursing knowledge and usability ($r = 0.757$). The weakest correlation was between collaborative gaming and active participation in patient care ($r = 0.220$). Three predictors were significant in the stepwise regression model. The regression model effectively predicted elements of learning clinical reasoning by gaming ($R2 = .49$, $F(3.157) = 50.925$, $p < .001$) (see Article III, Table 4). Usability, application of nursing knowledge and exploration had a positive and significant relationship with learning clinical reasoning through gaming (Article III).

Based on the results, usability was the most important factor explaining learning clinical reasoning through gaming (see Article III, Table 4). The results revealed that a majority of the students experienced the game as being suitable for social services and healthcare studies and useful for learning clinical reasoning (Table 5). Also, a majority felt that playing increased their interest in learning clinical reasoning. They felt that studying by playing was fun and that it motivated them to study. Some of the students found the game difficult to use and were unable to play it (Table 5). The results from the user testing showed similar results (Article IV). The challenges with the user interface related to its intuitiveness and the game's logic and rules, which participants noted needed improvement. Some players felt that the user interface was hard to understand. The game had also some technical problems. Some players felt that playing was easy and that it felt like playing a game for leisure. Some of the players felt that they learnt something new by playing the game, but others did not. Some students felt that, though the scenarios were realistic, playing the game did not replace clinical practice, hands-on experience and taking care of real patients. (Article IV)

Application of nursing knowledge was a second important factor explaining learning clinical reasoning through gaming (see Article III, Table 4). Students reported that, during playing Prototype II, they applied their theoretical knowledge and previous experience of patient care. They also stated that the game let them combine theory and practice (Table 5). The weakest factor explaining the learning of clinical reasoning through gaming was exploration (see Article III, Table 4). Using Prototype II, students were able to test their competence, learn by trial and error and make mistakes safely and learn by tryouts (Table 5). The user testing revealed that repeating the scenarios was good for learning. Overall, the players felt that the game tested knowledge and competence and helped them to recall important factors related to nursing theory. However, some felt that tryouts the game's scenarios inhibited thinking. (Article IV)

Findings revealed that authentic patient-related experiences, feedback and reflection have an indirect effect on learning clinical reasoning (Article III). These factors alone do not explain why students learned while playing, but they had a strong background influence and, thus, are important elements in simulation games for learning clinical reasoning (see Article III, Figure 3). Authentic patient-related experiences were realised well in Prototype II. Students reported that the patient scenarios provided enough information, were realistic and were sufficiently challenging. However, once again, patient care and interaction did not feel real (Table 5). User testing supported this finding (Article IV). The visual aspect of the game was reported to be professional and reliable. However, patients' facial expressions and gestures were incomplete, and players wanted to see more visual cues in the patient and the environment. There was too little interaction between the game and the player. Players' opinions about the scenarios and their difficulty varied. Some found them to be appropriately difficult, but others found them to be too easy. The latter group wanted more challenging scenarios that corresponded to their skill levels. Players requested longer cases, multiple choices for nursing interventions, more incorrect options (not options which are obviously wrong, however) and cases with varying difficulty levels. Players wanted the scenarios' difficulty to be scaled to the players' progress; for example, a player might unlock more challenging levels as he completes lower levels. (Article IV)

The students who played with Prototype II reported receiving immediate and continuous feedback during playing and more after completing scenarios (Table 5). They also found that mistakes were corrected during gaming. Immediate feedback made them consider their decisions carefully, and they felt that, through continuous feedback, they could develop their competency. They also reported that receiving feedback after completing a scenario allowed them to assess their competence. The possibility of following their progress in a single scenario during the game was not effectively realised. (Table 5) Players felt that receiving immediate feedback in the forms of scoring and colour effects constituted an effective feedback system. They liked seeing their points in real time since it allowed them to know whether their decisions were correct. Players wanted more information regarding why decisions were right and wrong. Quite a few of them wanted the game to provide feedback at the end of each scenario so that they could track the development of their competence and determine how to improve their future performances. It was reported that levels and reward systems should be linked together and that new levels should be unlocked based on players' competence. (Article IV)

During gaming, students made decisions by considering their experiences in patient care and the different options with which they were presented (Table 5). The game caused them consider their decisions more carefully. They pondered decisions together with other students to a moderate degree, and they perceived that their professionalism advanced moderately through the gaming. In user testing, students reported that the game pushed them to reflect on their knowledge and skills. The frequent reasoning encouraged by the game helped them to learn more. (Article IV)

Collaborative gaming and active participation in patient care had weak positive relationships with learning clinical reasoning through gaming (see Article III, Table 3). However, collaborative gaming had a strong positive correlation with reflection ($r = 0.701$). Most of the students felt that collaborative gaming was fun, and more than a third felt that they had learned from their fellow students. Over 80% felt that they had participated actively in the simulated patient care (Table 5).

Table 5. Nursing students' experiences of playing and learning from the simulation game (N = 163–166)

	Definitely agree		Some-what agree		Some-what disa-gree		Definitely disagree		M	SD
	n	%	n	%	n	%	n	%		
Authentic patient-related experiences M = 3.0, SD = 0.509, Cronbach's alpha = 0.718										
Patient scenarios were realistic	77	47.20	82	50.30	4	2.50	0	0.00	3.45	0.55
Patient scenarios had enough information	92	56.40	53	32.50	14	8.60	4	2.50	3.43	0.75
Patient scenarios were sufficiently challenging	82	50.00	67	40.90	14	8.50	1	0.60	3.40	0.67
Patient care felt real	10	6.10	69	42.30	60	36.80	24	14.70	2.40	0.81
Patient interaction felt real	13	7.90	64	39.00	51	31.10	36	22.00	2.33	0.91
Active participation in patient care										
I participated actively in patient care	51	31.50	82	50.60	25	15.40	4	2.50	3.11	0.75
Application of nursing knowledge M = 3.25, SD = 0.633, Cronbach's alpha = 0.751										
The game combines theory and practice	71	43.8	62	38.3	24	14.8	5	3.1	3.23	0.814
I applied theoretical knowledge while playing	75	45.5	72	43.6	15	9.1	3	1.8	3.33	0.717
I applied my previous experience of patient care while playing	69	41.8	60	36.4	35	21.2	1	0.6	3.19	0.788

	Definitely agree		Some-what agree		Some-what disa-gree		Definitely disagree		M	SD
	n	%	n	%	n	%	n	%		
Exploration M = 3.52, SD = 0.492, Cronbach's alpha = 0.753										
I tested my competence in the game	81	49.4	61	37.2	20	12.2	2	1.2	3.35	0.74
I learned by trial and error in the game	86	53.1	65	40.1	9	5.6	2	1.2	3.45	0.66
I could make mistakes safely in the game	122	74.4	34	20.7	8	4.9	0	0	3.7	0.558
I learned by tryouts in the game	106	64.6	49	29.9	7	4.3	2	1.2	3.58	0.636
Feedback M = 3.1, SD = 0.549, Cronbach's alpha = 0.851										
I received immediate feedback on my decisions	80	49.10	60	36.80	17	10.40	6	3.70	3.31	0.81
My mistakes were corrected during gaming	65	39.90	76	46.60	17	10.40	5	3.10	3.23	0.76
I received continuous feedback on my performance	68	42.20	61	37.90	27	16.80	5	3.10	3.19	0.83
I received feedback after a completed scenario	53	32.30	74	45.10	28	17.10	9	5.50	3.04	0.85
I could follow my progress in the game	31	19.00	60	36.80	63	38.70	9	5.50	2.69	0.84
If I received immediate feedback, it made me consider my decisions more carefully	68	41.20	76	46.10	20	12.10	1	0.60	3.28	0.70

	Definitely agree		Some-what agree		Some-what disagree		Definitely disagree		M	SD
	n	%	n	%	n	%	n	%		
If I received continuous feedback, I could follow my competency development	54	33.10	74	45.40	34	20.90	1	0.60	3.11	0.75
If I received feedback after a completed scenario, it revealed my competence	47	28.50	79	47.90	35	21.20	4	2.40	3.02	0.77
Reflection M = 2.99, SD = 0.573, Cronbach's alpha = 0.682										
I considered different options in the game	73	44.20	70	42.40	21	12.70	1	0.60	3.30	0.71
The game made me consider my decisions	63	38.20	86	52.10	13	7.90	3	1.80	3.27	0.68
While playing, I considered my own experiences in patient care	54	32.70	69	41.80	30	18.20	12	7.30	3.00	0.90
While playing, I considered decisions together with other students	42	25.50	61	37.00	30	18.20	32	19.40	2.68	1.06
My professionalism evolved by gaming	27	16.50	67	40.90	52	31.70	18	11.00	2.63	0.89
Collaborative gaming M = 2.94, SD = 0.837, Cronbach's alpha = 0.759										
Collaborative gaming was fun	60	36.60	77	47.00	19	11.60	8	4.90	3.15	0.81
I learned from my fellow students by collaborative learning	43	26.10	64	38.80	29	17.60	29	17.60	2.73	1.04

	Definitely agree		Some-what agree		Some-what disa-gree		Definitely disagree		M	SD
	n	%	n	%	n	%	n	%		
Usability M = 3.09, SD = 0.606, Cronbach's alpha = 0.873										
The game is suitable for social services and healthcare studies	83	50.90	61	37.40	13	8.00	6	3.70	3.36	0.78
Studying by playing was fun	75	46.00	63	38.70	20	12.30	5	3.10	3.28	0.80
The game is useful for learning clinical reasoning	60	36.60	74	45.10	26	15.90	4	2.40	3.16	0.78
Playing increased my interest in learning clinical reasoning	55	33.30	75	45.50	30	18.20	5	3.00	3.09	0.80
The game was easy to use	52	32.10	74	45.70	32	19.80	4	2.50	3.07	0.79
I understood how to play the game	45	27.80	55	34.00	54	33.30	8	4.90	2.85	0.89
The game motivated me to study	36	22.10	72	44.20	46	28.20	9	5.50	2.83	0.84

Scale: 4 = definitely agree to 1 = definitely disagree

4.6 Design principles for the simulation game

The design principles for simulation games were generated based on the results of the design-based research process (RQ 4; Articles I–IV). The design principles generated here are specific to an educational context (learning in nursing education) accompanied by a domain subject (clinical reasoning). Therefore, the design principles can be said to be pedagogical (Arnab et al., 2015; Bellotti et al., 2011). The principles are characteristic of the design itself (substantive design principles), which was generated based on theoretical and empirical knowledge via iterative cycles using mixed methods (procedural principles) (van den Akker, 1999 in Plomp, 2013). Next, the design principles for simulation games are presented to guide future designers when designing and developing simulation games for learning clinical reasoning. The principles were applied in further developing the simulation game discussed in this study (Figure 6).

Figure 6. Screenshot of beta version (2015)

If you want to design a simulation game for the purpose of learning clinical reasoning in nursing education then you should give the game the following characteristics (see van den Akker 1999, in Plomp, 2013) (Figure 7):

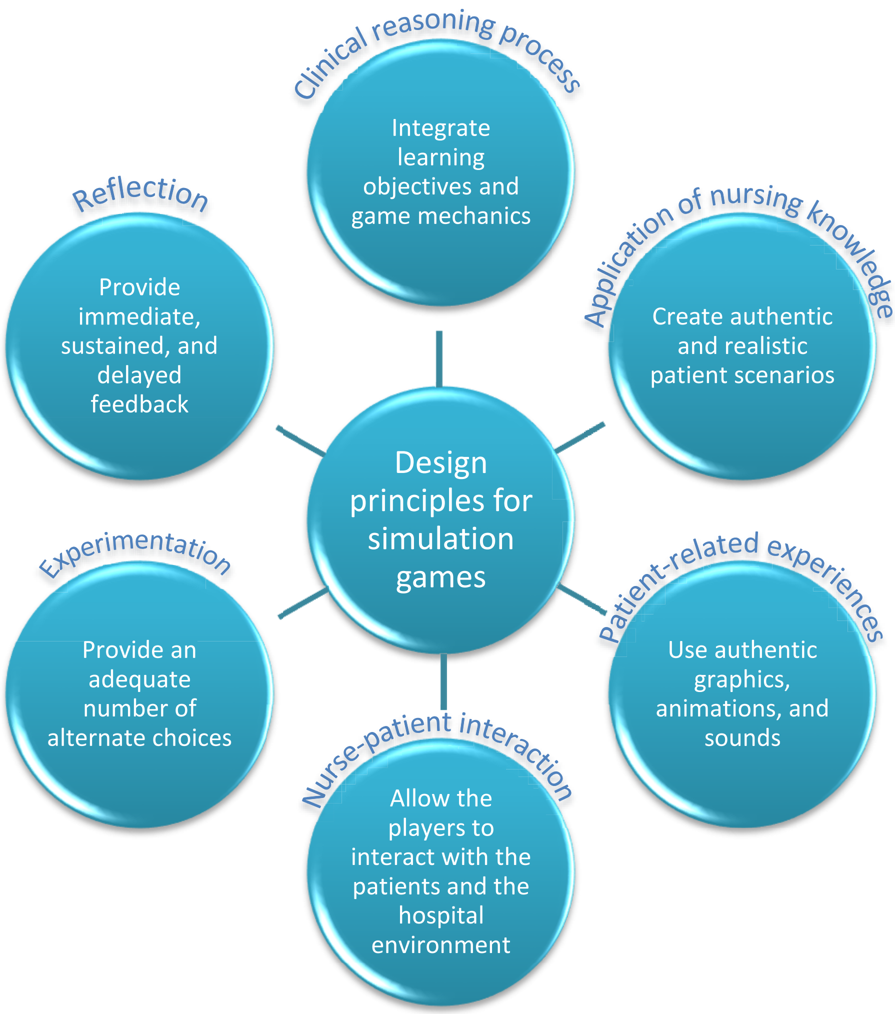

Figure 7. Design principles for simulation games for learning clinical reasoning

Design Principle One: Integrate learning objectives and game mechanics in a way that replicates real clinical reasoning processes.

Description: The overall learning objective in the simulation game developed in this study is to learn clinical reasoning. The learning objectives in the scenarios include assessing patients' clinical status using the ABCDE approach, recognising patient deterioration and changes in a patient's condition and implementing nursing interventions. To ensure that students could use a systematic approach to follow the phases of the clinical reasoning process, the game mechanics needed to be built around the clinical reasoning process. The game guides learners through collecting and processing information, identifying problems and issues, establishing goals, taking action and evaluating outcomes. The game allows a player to move forwards and backward between interview, assessment and implementation sections: non-linear gameplay allows a player to proceed in the clinical reasoning process based on the patient's clinical condition. This replicates a real clinical situation and, thus, enables learning.

Design Principle Two: Create authentic and realistic patient scenarios that allow players to apply their nursing knowledge.

Description: The simulation game consists of patient scenarios, which are events designed around a specific situation requiring clinical reasoning. Application of nursing knowledge refers to the requirement for players to apply theoretical and practical nursing knowledge while playing. This helps students to practice prioritisation and to learn about procedures (such as clinical protocols) that can be applied in real-life patient situations. Realistic patient scenarios involving varying clinical conditions and various patients provide opportunities to apply knowledge and learn clinical reasoning. Scenarios should be challenging and correspond to the skills of the players in order to engage learners.

Design Principle Three: Use authentic graphics, animations, and sounds to create authentic patient-related experiences.

Description: Authentic audio-visual representation supports real-life experiences. Visual authenticity refers to patient appearance and medical devices in terms of graphics, and patient movements, facial expressions and gestures in terms of animations: 3D character (the patient) in a 3D environment representing hospital ward, with authentic reactions and equipment. A patient's clinical condition and any changes can be observed with the help of animation. Authentic sounds are important in representing a realistic context and include both hospital noises and patients' voices and sounds. Sounds suggesting clinical conditions direct the player to the patient's problem, helping to prioritise nursing interventions.

Design Principle Four: Allow the players to interact with the patients and the hospital environment.

Description: Interactivity refers to the interaction (i.e. the action-reaction cycle) between the player and the game environment: students' reactions to the patients' clinical condition and patients' reactions to the care given during playing. This enables players to see the consequences of their actions. Nursing is essentially about interactions between patients and nurses: the more effectively the game enables interaction, the more realistic and engaging the learning experience will be. Immersion refers to players' experience of being drawn into the game so that they have the feeling or perception of being part of the game environment. The simulation game focuses on genuine patient concerns and the willingness of the player to help the patient. Interactivity supports immersion, which can be undermined by a lack of authenticity.

Design Principle Five: Provide an adequate number of alternate choices to allow for active experimentation.

Description: During play, learners can actively experiment by considering different choices (thinking) in relation to the patient's clinical condition and by making decisions about how to react to the patient's deterioration (action). The game provides possibilities for exploration, including opportunities for players to test their competence, make mistakes safely, learn by trial and error, and try out strategies in the game. Playing against a time limit compels players to practice quick decision making. The scenarios can be repeated, which helps learners to internalise and automatise procedures.

Design Principle Six: Provide immediate, sustained, and delayed feedback in order to trigger reflection.

Description: Receiving immediate, sustained, and delayed feedback causes learners to consider their decisions and enables them to track their competency development. Reflection on the learning process is triggered by feedback. While playing, learners consider different options and make decisions based on their experiences with patient care. Additionally, they consider the decisions they have made. Types of immediate feedback include correcting errors, scoring, patient reactions, in-game facilitator's comments, and the effects of success and failure. Sustained feedback refers to changes in patients' clinical conditions during gaming, the accumulation of scores, and documentation of players' choices in the log. Delayed feedback refers to players' total scores and description of correct performance. Feedback allows learners to consider issues of cause and effect. The provision of reasoning helps them reflect on both the decisions made and the underlying knowledge gained.

5 Discussion

5.1 Discussion of results

The aim of this study was to obtain knowledge on the learning of clinical reasoning through game-based simulation. This knowledge was to be used in developing and embedding new learning methods for clinical reasoning in nursing education. The study generated design principles for simulation games, and the researchers and participants designed and developed a simulation game for learning clinical reasoning. In developing this game, the study investigated nursing students' learning through gaming. The game was developed using iterative cycles (RQ 4); meanwhile, nursing students' experiential learning processes during gaming (RQ 1), their experiences of learning clinical reasoning by playing a simulation game (RQ 2) and the game elements that affected the learning of clinical reasoning (RQ 3) were investigated. This study contributed significantly to research on game development in nursing education through the design principles that it has generated. It provides knowledge about nursing students' learning of clinical reasoning through game-based simulation. The reusable design principles that it generated through a design-based research process can be utilised in similar research, development and implementation in other contexts in the future.

The study has five main results. First, game-based simulation is beneficial for learning clinical reasoning. Second, by combining game elements and simulation in simulation game design, learners' engagement with the learning experience can be enhanced. Third, elements in a game-based simulation that affect learning clinical reasoning in nursing education are usability, application of nursing knowledge, and exploration. Authentic patient-related experiences, feedback, and reflection have an indirect effect on learning clinical reasoning and are thus important. Fourth, the design-based research process produced new knowledge about learning clinical reasoning through game-based simulations. The design-based research proved to be an applicable methodology for designing and developing educational simulation games for healthcare education. Fifth, the study facilitated the generation of reusable design principles for simulation games. In the following sections, the results regarding these main results are discussed. They are presented in Figure 8.

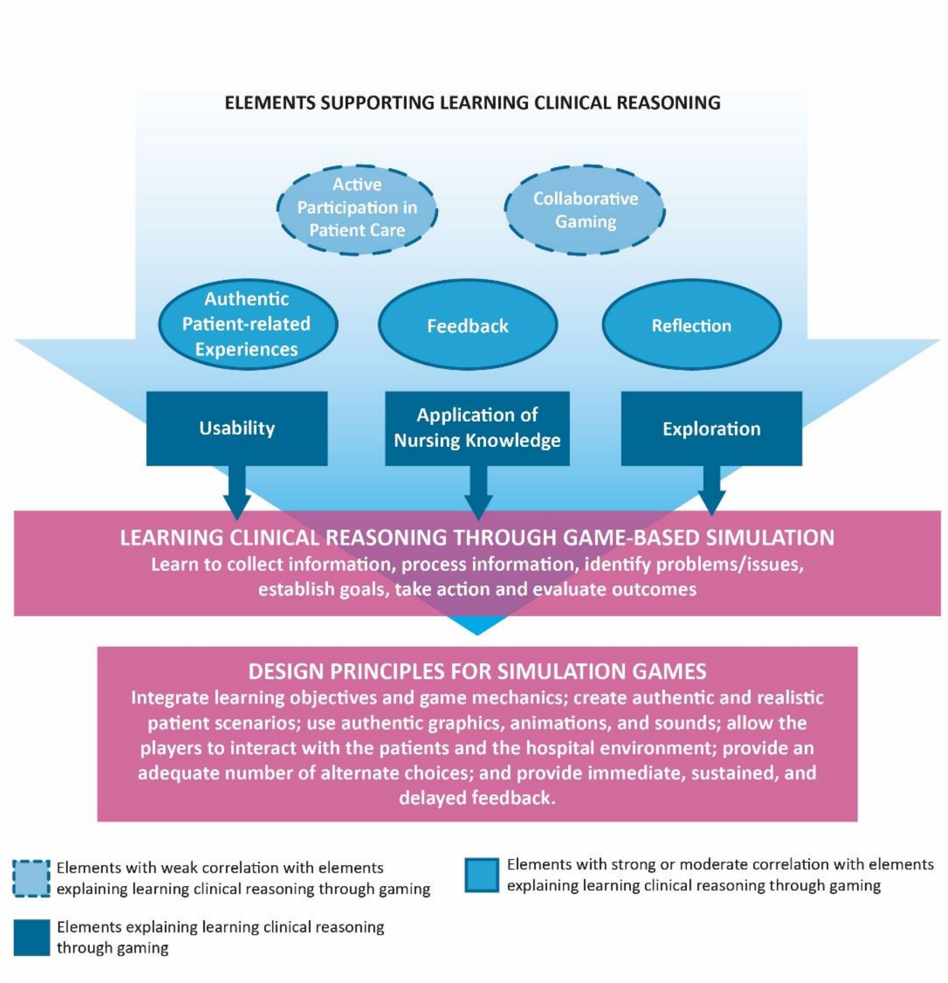

Figure 8. Summary of the study's findings

5.1.1 Learning clinical reasoning through game-based simulation

This study was undertaken in response to the urgent need to develop and evaluate new options for the learning of clinical reasoning in nursing education. Research has shown that nursing students lack knowledge and skills in detecting and managing changes in patients' clinical conditions (Bogossian et al., 2014; Kajander-Unkuri et al., 2014a) and that they must be taught to recognise, monitor and manage critically ill patients (see Soar, 2015). The literature shows that serious games are a potential learning method (Cant & Cooper, 2014; de Freitas, 2007; Forsberg et al., 2011; Graafland et al., 2012; Petit dit Dariel et al., 2013) for practicing clinical reasoning in an engaging and immersive learning environment. The most important, clinically relevant finding was that clinical reasoning skills can be enhanced by game-based simulations. In this study, the phases of Lewett-Jones et al's (2010) clinical cycle reasoning that consists of six phases were applied when investigating nursing students' learning of clinical reasoning by playing games. In this study, a majority of students felt that they learned the phases of clinical reasoning quite well or moderately well. It was found that, while the activities of collecting information and taking action require concrete actions, the activities of processing information, identifying problems and issues, establishing goals and evaluating outcomes require thinking. As Squire (2006) noted, games offer designed experiences in which students can learn; in this case, the game provided opportunities for learning clinical reasoning by requiring students to act and think while playing. Previous research has established that a systematic approach to following the phases of the clinical reasoning process can help nursing students to learn clinical reasoning (Cook et al., 2010; Forsberg et al., 2011; Hart et al., 2014; LeFlore et al., 2012; Lewett-Jones et al., 2010; Petit dit Dariel et al., 2013; Tanner, 2006). Based on the results of this study, building the game mechanics around the clinical reasoning process enables learners to go through the phases of the process. These results are consistent with those of Petit dit Dariel et al. (2013), who found that learners begin to systematically apply the clinical reasoning model and to prioritise interventions.

Another important finding was that learners' engagement in the learning experience could be enhanced by combining game elements and simulations in simulation game design. Kolb's (1984) experiential learning theory is the most used learning-theory foundation for game-based learning (Wu et al., 2012), and this study considered experiential learning processes to be an important component of professional learning in nursing education when using simulation games. User experience is significant in learning by using games (Kiili et al., 2012), and the most interesting finding of this study was that, in order to provide significant learning experiences for nursing students, educational games need to share some of the characteristics of leisure games. These include visual authenticity, immersion, interactive 3D environments, high-quality animation, graphics and sounds and immediate, sustained and delayed feedback. This finding may be explained by the fact that students who enter nursing education are already immersed in the online world through their smartphones, tablets, personal computers and laptops. According to Kajander-Unkuri et al. (2014), nursing students rate their competence in utilising information technology very highly. Their expectations, attitudes and learning styles reflect this environment, and educators must use learning methods that will support their learning. Keskitalo (2012) found that adult learners had high expectations for learning in virtual reality and simulation-based learning environments in comparison to younger students. Adult students particularly expected to be able to transfer learning to real patient care after training. It is interesting to note that in the present study both the heavy and occasional digital game players felt that they learned more about clinical reasoning than those who did not usually play at all. This may be because those who play have more experience reading the signs of the game system than those who do not play (see Squire, 2006). This tendency may influence a player's personal game experience and, therefore, their capacity to learn by playing. This supports the notion of de Freitas et al. (2010) that learners unfamiliar with 3D environments do not benefit from the virtual learning experience. In the current study, students felt that studying by playing was fun and motivating, which indicates that they were engaged in learning during gaming.

The present findings indicate that usability is the most important factor in learning clinical reasoning through game-based simulation. The results confirm the findings of Fonseca et al. (2015) and Zhua et al. (2012) that the usability of a game has an impact on its educational value. Students' perceptions of the usefulness of a game are also of great importance in terms of learning. One important finding is that simulation games need to provide an adequate number of choices to allow for active experimentation. These results show that one of the most important factors relating to the perceived use of a game is exploration while playing. Students felt that the game was a safe learning environment in which to learn from mistakes and that they could learn by tryouts and by trial and error. This aligns with previous studies, the findings of which show that the opportunity to make mistakes and learn from them without consequences for real patients is an important factor in student learning (Foronda et al., 2014; Heinrichs et al., 2008; Kidd et al., 2012). This study's results indicate that students were able to test their competence using the game, which echoes Forsberg et al. (2011), who found that students regarded the virtual cases approach as a good way of assessing their ability to solve clinical problems. Students felt that working with cases increased their self-confidence in solving clinical problems. This study revealed that, by repeating the game, students could internalise and automate procedures.

Another important factor in the game's effectiveness is the inclusion of authentic and realistic patient scenarios that allow players to apply nursing knowledge while playing. The present findings indicate that the application of nursing knowledge is strongly connected with learning clinical reasoning. This aligns with the findings of previous studies (see Blakely et al., 2009; Forsberg et al., 2011; McCallum et al., 2011), in which nursing students learned to make decisions by applying previously acquired theoretical and practical knowledge in virtual scenarios. The results also confirm the findings of Guise et al. (2012) and Heinrich et al. (2012) that students are able to become actively involved with patients in virtual scenarios. This requires that the patient scenarios be realistic and that the virtual patient and the game environment authentically replicate real-life clinical situations. This is a key factor in learning clinical reasoning, which always relates to a particular patient and situation (Tanner, 2006). These results seem to be consistent with other research which have emphasised that realistic and authentic patient scenarios are paramount in simulation games (Cook et al., 2010;

de Freitas, 2007; Forsberg et al., 2011; Guise et al., 2012; Heinrichs et al., 2010; Honey et al., 2012; Huwendiek et al., 2009; LeFlore et al., 2012; Rizzo et al., 2011). Based on these results, authenticity of patient scenarios requires realistic and challenging clinical conditions. The difficulty level should correspond to the skills of the players. This echoes the observations of Kiili et al. (2012) and Hamari et al. (2016) that educational games should provide challenges that are balanced with learners' skill levels. This study indicates that during play, students can make decisions, use theoretical knowledge, and practice procedures that can then be implemented in real-life nursing, which is highly valued by students (Blakely et al., 2010). Seeing the consequences of their decisions prepares students for decision-making situations and, in this way, helps students become more confident in their abilities. Seeing the consequences of decisions prepares students for decision-making situations and in this way, become more confident in their abilities. Another interesting result is that students reported learning to make decisions in co-operation with other students even though this was a single-player game. It seems that playing caused students to discuss the patient scenarios and consider decisions together, and thus learn from each other. These opportunities for social relatedness and collaborative decision making may further enhance learning. This prepares students for real situations, in which decisions will be made in collaboration with other professionals participating in patient care in a clinical setting.

One interesting finding is that, to enable learning by playing, a game must engender patient-related experiences. The findings of the current study highlight the importance of audio-visual authenticity since this strongly supports the feeling of a real-life experience. This study revealed that authentic patient-related experiences have a positive relationship to learning clinical reasoning. If patient scenarios are not realistic and virtual patients are not lifelike, immersion can be diminished, which, in turn, can reduce learning. Prior studies have noted the importance of authentic representation of clinical practice in simulations (Bland et al., 2014). In this study, authentic representation of clinical practice refers to a 3D character (the patient) in a 3D environment representing the hospital ward, with authentic reactions and equipment. Previous studies have indicated that replication of real-life experience, authentic behaviour of virtual patients, medically important interactive objects and typical medical clues influence how lifelike the learning experience is (Dev et al., 2011; Lapkin & Lewett-Jones, 2011; Rizzo et al., 2011).

Another important finding is that players want to interact with the game environment. Nursing is essentially about interactions between patients and nurses, and the findings here indicate that interaction in the game is essential: the more effectively the game enables interaction, the more realistic and engaging the learning experience will be. This finding may be explained by the fact that, when learners react to the patients' clinical conditions in the game, they can see the consequences of their actions from the patients' reactions to the care that the learners provide. Players felt that these reactions were the best feedback that they received during gaming. These results match those of earlier studies suggesting that interaction between learners and a virtual environment increases realism and thus supports learning (de Freitas & Neumann, 2009; Dev et al., 2011; Huwendiek et al., 2009; Petit dit Dariel et al., 2013).

Reflection during and after gaming, which is triggered by feedback, is connected with the successful learning of clinical reasoning through gaming (Erhel & Jamet, 2013; Goldberg & Cannon-Bowers, 2015; Ketamo & Suominen, 2010; Tsai et al., 2015). According to Kuiper and Pesut (2004), reflective clinical reasoning depends on the development of critical and reflective thinking, and these results show that simulation games can be used for those purposes. The results of this study indicate that, in the game, students considered different options and made decisions using their experiences with patient care. These results showed that receiving feedback on decisions cause students to consider their decisions, and enable them to track their competency development. Further, this study indicated that feedback provided only at the end of the learning situation comes too late; the student cannot effectively connect the feedback with their actions. However, feedback at the end is nonetheless necessary as it allows students to consider issues of cause and effect and combine their experiences with their knowledge of nursing and patient care. In particular, students emphasised the significance of reasoning indicating that they wished to gain deeper knowledge rather than learn only from memory. Self-reflection is connected to professional development (Bulman et al., 2012), and in the present study, 41% of the students responded that their professionalism evolved through the gaming.

5.1.2 Design-based research in generating design principles for simulation games

A design-based research methodology was adopted to gain a detailed understanding of learning clinical reasoning through game-based simulation. This knowledge was used in order to design and develop a simulation game that has educational value. This design-based research process facilitated the generation of design principles based on theoretical and empirical knowledge gained through iterative cycles. The research was conducted through collaboration among researchers, nurse educators, students, programmers, a 3D artist and interface designers in a real-world setting. The results of this study support Wang and Hannafin's (2005) argument that design-based research leads to the development of knowledge that advances pragmatic and theoretical aims. Working through the iterative cycles of design, development, testing and refinement of the simulation game produced new theoretical knowledge which evolved throughout the process. The knowledge was applied instantaneously to the design principles; it contributed to the development of the simulation game and was tested by its intended user group to evaluate its effectiveness in complex real-life settings (see Sandoval & Bell, 2004). Wang and Hannafin (2005) contend that the value of theory depends on how it can improve practice. This study provided an important opportunity to advance theory and practice in relation to simulation game design and development. However, a note of caution is due: principles are generated to support designers in their tasks but cannot guarantee success (Plomp, 2013).

The results of this study are in agreement with studies indicating that design-based researchers draw from multiple disciplines (Sandoval & Bell, 2004). In this study, knowledge from nursing science, educational science, technological science and game design were used. This was necessary to understanding the complexity of the phenomenon of learning clinical reasoning through game-based simulation. As an example, to understand how nurses make clinical decisions, knowledge of clinical reasoning is crucial. However, building this knowledge into game mechanics requires knowledge of game design and programming.

These results further support the importance of collaboration with nurse educators, researchers, learners and game developers by using participatory methodologies in developing simulation games. As mentioned earlier in the theoretical framework of the study, there exists a gap between game developers, learners, educators and curriculum designers (de Freitas, 2007; Winters & Mor, 2008; Wu et al., 2012). The results of this study indicate that it is paramount, in designing and developing games for educational purposes in the healthcare sector, that the development team consists of experts from many fields: researchers, nurse educators with work experience in nursing, students, programmers, 3D artists and interface designers. Another important insight provided by this study is that the collaboration between these experts needs to be intensive. Finding the common vocabulary for understanding each other requires continual open discussions and reflections. As a practical result, working alongside one another improves the quality of co-operation and, thus, the results of the work. This is in line with Barab and Squire's (2004) notion that multiple aspects need to be considered simultaneously when participants from multiple disciplines are involved in a design process.

Together, these results provide important insights into the significance of multidisciplinary collaboration, use of participatory methodologies and user-oriented game design. My personal growth as an educational design researcher relates to these three issues. Plomp (2013) contends that a researcher's adaptability influences the synergy between research and practice. During the design process, the researcher needs to be prepared to take on additional roles, such as that of a designer, advisor or facilitator, without losing sight of his primary role as a researcher. The researcher needs to tolerate uncertainty and to allow the study to be influenced by partners and participants. This study has been an enormous learning experience for me. During this process, I have had multiple roles. As a nurse and nurse educator, I was aware of the deficiencies in nurses' competence in detecting signs of deterioration in hospitalised patients. Due to this, I understood that we educators need to prepare our students more effectively. At the same time, I had an opportunity to develop a new learning environment for healthcare education. The combination of these two factors was the starting point of my research and of my personal development towards the role of an educational design researcher. In the beginning of the research process, I strongly identified my role as that of a nurse educator. As the research progressed, I started to identify myself as an educational game designer and developer. At this point, I was privileged to work in close collaboration with game designers, and in doing so, I learned a remarkable amount about games, gaming experience and game development. My active involvement in all phases of the game's design helped me develop skills in creating storylines, determining goals, inventing rules and challenges, and designing characters, backgrounds for scenes, and the written content of the patient scenarios. I used my knowledge of nursing and healthcare to create a game that nursing students find credible. Additionally, I developed skills in managing the game development process and testing the game. Throughout the process, I have been responsible for managing and conducting the research, and through this, my identity as a researcher has evolved. However, my role as an educational design researcher does not exist in a vacuum. It exists in multidisciplinary collaboration with students, colleagues, researchers, designers and developers, all of whom have expertise, which they use to help others achieve common goals. By working together using participatory methodologies, we can enhance educational practices and solve real-world problems. Finally, by involving the end-users as partners in the design process, we can create learning methods that engage students to learn almost as if by accident.

5.2 Ethical considerations

The research was established according to ethical guidelines (Burns & Grove, 2005; Finnish Advisory Board on Research Integrity, 2009). The key research values that needed to be considered from an ethical standpoint were the rights to self-determination, privacy, anonymity and confidentiality, fair treatment and protection from discomfort and harm (Burns & Grove, 2005).

The research was ethically justified because its aim was to obtain knowledge on learning clinical reasoning through game-based simulation to be used in developing and embedding new learning methods for clinical reasoning in nursing education. The purpose of this research was to generate design principles for simulation games that enhance learning and to design and develop a simulation game for learning clinical reasoning. Furthermore, to enable development of such a simulation game that enhances learning, the purpose was to investigate nursing students learning through gaming. The participation of nursing students in the research was essential because, in game development, it is important to involve users in the design process from the early stages. Permission to conduct the research was obtained from the directors of the universities of applied sciences. Each participant was treated fairly and respectfully.

Students in the first cycle of testing and refinement of the simulation game (Article I) volunteered to participate on the basis of their interest in simulation game design, and all were commencing a thesis related to game development. The participants were familiarised with the setting beforehand. The researcher discussed the purpose, the content and methodology of the study with participants beforehand and informed them that they would be recorded during the study. They were informed that video recording offers a means of close documentation and observation and makes an important contribution in understanding learning processes and more effectively designing new learning environments (Derry et al., 2010). They were told that the researchers' interest was in learning while playing, not in their competency.

Video research is potentially risky with regard to participants' anonymity, and privacy is a paramount concern. Students who participated in the study received verbal and written information. They received an information sheet about the research (Appendix 2), and they were asked to sign a form confirming their permission and willingness to participate. They were told that they could withdraw from the study at any time. They were told that the data would be only used for research, that it would not be available to anyone outside the research team and that in no circumstances would it appear on the web or be used for commercial gain (see Derry et al., 2010; Heath et al., 2011). The information sheet explained how long the data would be kept and by whom.

Because participants who are recorded cannot be ensured of anonymity (Derry et al., 2010), they were able to choose whether to consent to video recording and to what purposes the researchers could use the recordings (Appendix 3). The participants were protected from discomfort and harm. In this study, the participants were not potentially vulnerable. They were able to give informed consent, and they knew that they were recorded. The study did not involve any sensitive topics affecting individual respondents. However, the recording may have induced stress in the participants. The participants remained in a set position during playing, and the cameras were placed in fixed positions, shooting close up with no panning or zooming. The interviews were conducted in a sensitive manner, minimising the risk of harm.

The researcher made several copies of all original recordings and stored them in a separate location. The data was not stored in a computer. The anonymity of the informants was protected by giving each informant a code number. The code number was used in the analysis of the video data and interviews, and no names were used. The data was transcribed so that only the codes were used. In the study report, visual representations were not used. Quotations from the data were presented while ensuring that participants could not be identified.

During the second cycle of testing and refinement of the simulation game (Articles I–III), informants' anonymity and confidentiality was assured. Members of the development team collected the qualitative data from the user testing. In total, 166 undergraduate nursing students and 60 intensive care unit nurses participated in these sessions. Participants were fully informed about the purpose, content and methodology of the study in the beginning of all gaming sessions; this was done orally and with an information sheet (Appendix 4). This discussion could have been carried out earlier, but since the sample was so big and there were so many gaming sessions, the researcher was not able to meet all participants beforehand. In addition, the participants should have been familiarised with the gaming setting before the gaming sessions. The quantitative data was collected from nursing students. I had taught most of the student participants before, and they knew my status in the organisation. However, I was not responsible for course evaluation and they were informed that participation does not effect on their evaluation. Participants were told that completion of the questionnaire was voluntary and that they could withdraw from the study at any time. It was assumed that, by answering the online questionnaire, participants gave their consent to take part in the study. Participants answered the questionnaire immediately after gaming, which may have produced socially desirable results. They participated in the gaming sessions as part of their studies, and they may have felt obligated to answer the questionnaire and evaluate the game and their learning more positively than they otherwise would have. The results were presented in a way that made identification of individual participants impossible. The data were stored in accordance with the ethical guidelines of the University of Helsinki.

5.3 Limitations of the study

Despite the many advantages of design-based research, there are also challenges. One of these is the transferability of design principles. The challenge lies in the fact that design-based research is conducted within a single real-world setting, which is always unique. Even if design principles are proven effective in the local context, they might not be valid in another context (Wang & Hannafin, 2005). However, more transferable results can be generated through iterative cycles, which reveal the limitations of the process; when limitations are revealed, designers can make the necessary changes in the design (Amiel & Reeves, 2008; Reeves, 2006; Wang & Hannafin, 2005). In this study, transferability was improved by organising a total of 23 gaming sessions during 2013 and 2014. Improvements in the simulation game were made regularly. Nevertheless, a warning should be given: even though the design principles for the simulation game were generated based on the knowledge gained through the iterative process, each context has unique characteristics that influence how these principles should be applied. As Plomp (2013) states, in design research, findings cannot be generalised to a larger universe. Another source of uncertainty is the applicability and transferability of the results across international educational systems. Educational systems vary across the world, and the requirements for nurses' competencies and responsibilities are different in different places. This study was conducted in Finland, and these results can only be extrapolated with caution. However, despite regional and cultural differences, common competencies appropriate for nursing students have been identified (Kajander-Unkuri et al., 2013). In particular, the efficient use of clinical reasoning transcends national boundaries. It can therefore be assumed that the results could be applicable outside of Finland. However, future studies on the applicability and transferability of the results across international educational systems are recommended.

One source of weakness in this study, which could have affected the results, is my limited use of game design and design research literature. Using more game design and design research literature would have benefited me during the generation of the design principles for the simulation game by strengthening my theoretical knowledge related to game design. The contribution of this study to researchers in those areas might be limited. However, the game design literature related to educational games was applied accompanied with several lines of evidence on elements that support learning of clinical reasoning. Because of this, the present study makes noteworthy contributions to game design as related to healthcare education by focusing on clinical reasoning and providing principles for developing simulation games for healthcare education. The findings of this investigation complement those of earlier studies indicating that the use of simulation games has positive effects on nursing students' learning. This study strengthens the idea that integrating game elements and virtual simulation is beneficial for learning. Therefore, the results of this study complement previous research evidence related to educational game design.

Another of the challenges of design-based research is the coherence of the research process and its stability over time and across methods. As Plomp (2013) notes, in each cycle, the findings from the previous cycle must be taken into account and, thus, the research design might change from one cycle to the next. This ever-changing research design can be weak if it is not well planned or conducted. Nonetheless, it is also one of the strengths of design-based research. In this study, mixed methods were used. Their use varied during the study's phases, increasing the objectivity, validity, credibility and applicability of the research (Wang & Hannafin, 2005). In total, 174 nursing students and 60 nurses participated in gaming sessions, and the data consisted of audio and video recordings from gaming sessions, observations of gaming, field notes, focus group interviews and questionnaires. There were some limitations in both the qualitative and quantitative methods. In the first cycle of testing and refining the simulation game, eight nursing students participated. For the purposes of investigating nursing students' experiential learning processes during gaming to determine which game characteristics support experiential learning (RQ1; Article I), the fact that only eight students participated can be considered a limitation, undermining the credibility of the results. However, the main weakness of this study phase was that the potential of video data was not fully exploited. The strength of video research is that it enables analysis of action, but in this study, mainly verbal conduct was analysed. However, by watching the videos, the researchers understood the deficiencies of the game and gaming experience.

In the second cycle of testing and refining the simulation game, quantitative methods were used to investigate nursing students' learning of the clinical reasoning process by playing the game (RQ2; Article II) and which elements explained their learning (RQ3; Article III). The fact that the instrument was developed for this study and was used here for the first time may reduce the validity of the findings. Additionally, the operationalisation of some items in the instrument may have been inadequate, which also may reduce the validity of the findings. The instrument was pilot-tested by nursing students. Two senior lecturers holding doctoral degrees in nursing science, one senior lecturer with experience of using games in nursing education and a professor of multimedia evaluated the instrument to ensure its content and construct validity. Some changes were made to variables, measurement scales and instructions to respondents. Students answered the questionnaire immediately after gaming; this positively affected the number of responses as all participants responded. The internal consistency of the instrument was good (Article I: Cronbach's alpha 0.647–0.832; Article III: Cronbach's alpha 0.682–0.922). Based on Cronbach's alpha, it can be concluded that the subscales were reliable. The generalisability of the results may be undermined by the fact that data were collected using nursing students' self-report questionnaire and were collected from only two universities. In addition, the game prototype used in this study was still in its development phase, and its validity had not been systematically evaluated.

The usability of the simulation game was explored by user testing. The number of participants in each gaming session in autumn 2014 was between 11 and 18. Two to four researchers observed the gaming and conducted the focus group interviews. One limitation of the study was that observers could not concentrate on observing individual participants; such observation would have enabled more in-depth understanding of users' behaviour, emotions and difficulties during gaming. Nevertheless, observing a large number of participants enabled the identification of various problems in the user interface and, additionally, helped the researchers to understand that the users had different viewpoints on what characteristics made the game good and useful for learning. The results from user testing were reflected when the game was developed further and, thus, the design principles have greater external validity than they would have if developed in a laboratory setting (see Wang & Hannafin, 2005).

The limitations of this study regarding the design-based research process consist of three issues. First, participatory methodology should have been better applied throughout the game design process. Nursing students should have been involved in the design process from the beginning. Instead, they tested Prototype I, and after that, they participated in workshops with the development team, helping to generate the design principles for Prototype II. Resources may have been saved if the students had the opportunity to influence the design principles earlier. Second, the lack of communication during the first design cycle may have hindered effective co-operation and, thus, mutual understanding of the game design. Long-term involvement in a working partnership can be a challenge (Leeman & Wardekker, 2011); during the first design cycle, collaboration between members of the development team was too infrequent, and it was not always clear to everyone how the development of the simulation game was progressing. The value of the knowledge gained through an iterative research process depends upon the partnership of the participants (Design-Based Research Collective, 2003).

Third, the development team should have included game designers from the beginning of the project. This would have enhanced the multidisciplinary design of the simulation game. Instead, the need for game designers was discovered during the first cycle of testing and refining the game, and only then were game designers recruited. Andrews et al. (2012) suggested a collaborative prototype design process as a method for user-centred design. This would have involved multiple design teams working independently on the same tasks. Such a design may have resulted in decreased cost and time spent, increased user comments and suggestions and more usability testing of a wider range of design options. However, this kind of collaborative prototype design process requires many people. Our development team was small, consisting of one or two persons from every field, which did not allow us to work in the way that Andrews et al. (2012) described. This, to some degree, influenced the creation of the prototypes and, thus, the results of the testing sessions and intended learning experiences.

The results may also have been affected by the fact that I had been teaching some of the participants, and they knew me well. I was in charge of the game's development as a part of my work. These factors might have produced socially desirable results. However, participants were encouraged to express their perspectives and opinions about the simulation game honestly and baldly so that the designers could make necessary improvements to the game.

5.4 Implications for education

The current findings add to a growing body of literature on serious games and their use for professional development in healthcare. The findings of this study have a number of practical implications. The simulation game developed in the study can be used for educating healthcare professionals in higher education and in vocational education and training. Through playing the simulation game, students can learn clinical reasoning and practice managing different clinical conditions and situations. For example, they might learn to monitor postoperative patients, manage anaphylaxis and recognise signs of breathing difficulties, cardiac arrest and stroke. The game can be embedded in all clinical nursing studies. In addition, the simulation game can be used for continuing training within healthcare organisations. It is recommended for use in developing clinical reasoning and, especially, in learning to detect signs of deterioration in hospitalised patients. The game is suitable for maintaining and developing professional competence, internalising treatment protocols and orientating new staff. It guides nursing students and nurses though a systematic approach to the observation of vital signs, which helps them to distinguish changes in a patient's condition, make clinical decisions, take actions and evaluate the outcomes of their actions. This, in turn, increases their competence in preventing cardiac arrests, other severe adverse events and even deaths. For these purposes, it is recommended that patient scenarios teach recognition of major contributing factors for deterioration, such as hypoxia, hypovolemia and coronary thrombosis. The simulation game is recommended for use as a part of regular staff education in the recognition, monitoring and management of the critically ill patient.

Different pedagogical approaches and models can be used in embedding game-based simulation to healthcare education. Simulation games can be used as a self-directed learning before and after theory classes to generate and sustain motivation. Simulation game can be used for acquisition and application of theoretical knowledge instead or along lectures. Educators can enrich classroom teaching by integrating gaming to other learning methods. It is well suitable as a pre-assignment before classroom simulation or practical training. Game-based simulation is also recommended to be used for collaborative learning by organising opportunities for reflection during and/or after gaming. In addition, the game can be used for assessment of clinical reasoning skills.

This study has generated design principles for simulation games. These principles can be applied when designing and developing other simulation games for educational purposes. The principles are especially applicable for healthcare disciplines but will also be useful in other fields. The decision-making process is built into the game's mechanics, and this structure can be adjusted to the special needs of various professions. The design principles generated here can help educational design researchers in similar research and development projects in new settings to select and apply the most suitable knowledge for specific design and development tasks. Through design-based research, the usefulness, applicability and feasibility of the design principles can be evaluated, and if necessary, changes to the design can be generated.

This research extends current knowledge of the expertise areas of which an ideal game development team should consist when developing serious games for educational purposes. First, an educational design researcher should manage the research process in collaboration with the other participants. Second, the team should have a project manager who manages the game development process as a whole. Third, the team should include end-users, such as students and other learners and educators and facilitators from educational organisations or other organisations with an educational capacity. Fourth, the team needs a content specialist who understands the specific subject to be learned. Fifth, the team should include a pedagogical expert who has the skills to embed the game into a curriculum. Finally, the heart of the team should consist of game designers and developers, including user experience designers, user interface designers, programmers and 3D artists. If there is an intention to commercialise the game, the team should include experts on business management and marketing.

This study has shown that students who have previously played digital games feel that they learn more by playing than those who have not played such games. In the future, the benefit of using serious games as a learning method is likely to increase. Students who enter nursing education are increasingly familiar with learning through gaming, and there will be fewer students who do not play digital games. This study's findings suggest that single-player games can be used for self-directed learning or for collaborative learning in the classroom to enhance the learning process and to offer more meaningful learning experiences. Nevertheless, educators should take into account those students who do not benefit from games or who do not have access to digital devices, especially as education becomes more digitalised. Higher education institutions should ensure that all students have access to educational technology. However, establishing competency with digital technology is the responsibility of lower level educational systems.

5.5 Implications for future research

It is recommended that further research on game-based simulation in educational context be undertaken using design-based research methodology. Solving practical learning problems with educational technology requires an understanding of complex real-life situations, including social relationships and varying cultural orientations. Design research takes all of this into account. In this study, the design principles were validated through a total of 23 gaming sessions. Further research should be undertaken to validate the design principles in other contexts or with other simulation games. The purpose of replicating the findings several times in various contexts is to ensure that the same results consistently occur. This, in turn, increases the credibility of the results, although it must be remembered that each context is unique. An interesting question for future research is this: if the design principles of this study cannot be replicated, or are replicated weakly, in different contexts, what kind of effect does this have on learning?

It is also recommended that a study focused on the implementation of game-based simulations in nursing curricula be undertaken. The embedding of new educational technology in curricula is still insufficiently effective. Involving students and teachers in curriculum development alongside design researchers promotes the intended use of simulation games (see de Vito Dabbs et al., 2009; Thursky & Mahemoff, 2007). There are still many unanswered questions about the most appropriate pedagogical model for combining game-based simulations with other learning methods. Design-based research can provide an applicable methodology with which game-based simulation can be successfully implemented into the curriculum.

Even though this study was conducted in Finland, the results can be generalised internationally because the challenges of detecting signs of deterioration in hospitalised patients are internationally recognised. Both the Finnish national resuscitation guideline (Resuscitation: Current Care Guidelines Abstract, 2016) and the European Resuscitation Council guidelines call for the early identification of patient deterioration and the importance of strengthening related competencies. It is unfortunate that the study did not include international data. Future research should investigate how to improve healthcare staffs' knowledge of and skills in identifying patients at risk for cardiac arrest or other severe adverse events in hospitals at the international level.

In recent years, there has been an increasing interest in using randomised controlled trials in evaluating the effectiveness of educational tools. However, some have criticised the use of randomised controlled trials in research on technology-enhanced learning environments (Reeves, 2006) since, in such studies, technology is seen as a tool rather than a learning process. However, further research might include quasi-experimental studies exploring how clinical reasoning skills may be augmented by playing games. For this kind of research design, any games used will need to be validated with more evidence on how game elements support learning. A further study could use the consensus-based framework presented by Graafland et al. (2014) for systematic, consistent, transparent and reliable assessments of simulation games' safety and validity.

5.6 Concluding remarks

Considering all of the evidence this study has produced, the contributions of this study to healthcare education, healthcare organisations, and the serious games industry are concluded separately.

Contributions to healthcare education

The present study confirms previous findings and contributes additional evidence that suggests that game-based simulations are a valuable learning method for healthcare education, and I recommend including it in curriculum. The present study should prove particularly valuable in demonstrating that simulation games can be used for teaching nurses clinical reasoning skills.

Contribution to healthcare organisations

The present study provides additional evidence with respect to the benefits of using simulation games to improve healthcare staffs' competence in the identification of patients at risk for cardiac arrest or other severe adverse events in hospitals. I recommend evaluation of the usefulness of simulation games as a part of regular staff education in the recognition, monitoring, and management of critically ill patients.

Contribution to the serious games industry

The study has gone some way towards enhancing our understanding of the importance of the involvement of healthcare professionals in serious game design and development. In order for serious games to add value to healthcare education, the essence of the profession needs to be built into the game, and here the contribution of professionals is priceless. With their assistance, the product can be improved, enhancing its chances for commercial success. I recommend engaging or recruiting healthcare professionals in game design at an early stage in the development process.

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Appendices

Appendix 1. Existing applications focusing on healthcare education in 2014 (The final report: educational games. An unpublished report conducted by OpalBlue Oy 21.2.2014).

Application/ product	Country	Manufacturer/owner	Content or target group
Virtuaalinen potilaspankki	Finland	University of Helsinki	Medical students
Medication Game	Norway	University of Stavanger & University of Agder	Medical calculation
Virtual hospital (in development phase)	Norway	Østfold Hospital and Attensi	Medical and nursing professionals: virtual hospital to train staff in various work processes
Attensi	Norway	Attensi	Gamified 3D simulation
MicroSim	Norway	Laerdal	Emergency medicine: prehospital, in-hospital and military training
SiMErgency (Simtech project)	Sweden	Karolinska Institutet & Forterrat	Healthcare students and students in uppoer secondary school: first aid skills
Web-SP	Sweden	Karolinska Institutet	Medical and nursing students: patient simulation system, with a built-in authoring tool
Aortaspelet	Sweden	Chalmers University of Technology, University of Gothenburg & Region Västra Götaland	Screening personnel: to train measuring abdominal aortic diameter in ultrasound images
Virtual hospital	Russia/USA	Institute of Rheumatology, Russian Association of Rheumatologists ja Abbott	Medical professionals
Virtual University Clinic	Russia	Ministry of Health of the Russian Federation	Medical professionals
abcdeSim	the Netherlands	VirtualMedSchool	Medical professionals
CliniSpace Virtual Sim Center	USA	Innovation In Learning, Inc.	Medical and nursing: patient assessment, decision making and interprofessional team communication
vSim for Nursing	e.g. USA, Norway	Laerdal	Nursing students: clinical reasoning skills, competence, and confidence
Virtual Heros	USA	Applied Research Associates	Medical Team-based Training

3DiTeams	USA	Duke University Meidcal Center	Medical and nursing students: medical education and team training
iHuman Patients	USA	i-Human Patients, Inc.	Students and clinicians: clinical decision making
Pulse! and vHelthcare	USA	BreakAway Ltd.	Healthcare professionals: clinical skills
Clinical Care	USA	VitalSims	Medical professionals: clinical skills, different patient scenarios for example SiMCare Diabetes
MedSIms	USA	TheraSim	Clinical skills

Appendix 2. Information sheet 2013

TIEDOTE TUTKIMUKSEEN OSALLISTUMISESTA

Hyvä tutkimukseen osallistuva!
Teitä pyydetään osallistumaan tutkimukseen, jossa on tarkoitus kehittää virtuaalista oppimisympäristöä hoitotyön opiskelijoiden kliinisten arviointi- ja päätöksentekotaitojen oppimisen tueksi. Virtuaalipotilaan kehittäminen on osa Metropolia ammattikorkeakoulun Terveys- ja hoitoalan yksikön Teho Pro -hanketta (2011-2013) ja sitä kehitetään yhteistyössä Metropolia ammattikorkeakoulun ja Ohjelmistoyrityksen kanssa. Virtuaalipotilaan kehittämisestä ja testaamisesta vastaavat TtM, lehtori Jaana-Maija Koivisto, Metropolia ammattikorkeakoulu ja Software Architect ohjelmistoyrityksestä.

Virtuaalipotilasta kehitetään opettajien ja opiskelijoiden palautteen perusteella design-tutkimuksen mukaisesti sykleissä, joissa suunnittelu, testaaminen, analyysi ja uudelleen suunnittelu vuorottelevat. Kehittämiseen liittyy myös väitöskirjatyö, joka hyödyntää testaustilanteissa kerättyä aineistoa. Tutkimukseen on saatu lupa Metropolia mmattikorkeakoulun terveys- ja hoitoalan johtajalta.

Virtuaalipotilasta testataan hoitotyön koulutusohjelman opettajilla ja opiskelijoilla. Tutkimuksessa ollaan kiinnostuneita siitä, miten virtuaalipotilaan sisällöt ja toiminnallisuudet tukevat opiskelijoiden oppimista. Testaustilanteessa tutkimukseen osallistujan pelisessio videoidaan ja tallennetaan ruutukaappausohjelmalla. Lisäksi opettajien ja opiskelijoiden kokemuksista kerätään tietoa haastattelemalla. Haastattelu nauhoitetaan.

Testaustilanne kestää noin kolme tuntia. Testauksen järjestää Metropolia ammattikorkeakoulun lehtori Jaana-Maija Koivisto. Osallistumisesi tutkimukseen on vapaaehtoista ja sinulla on mahdollisuus keskeyttää osallistuminen tutkimukseen heti niin halutessasi. Hankittu aineisto suojataan ja säilytetään sekä sitä käsitellään luottamuksellisesti.

Lisätietoa tutkimuksesta voitte kysyä lehtori, terveystieteiden maisteri Jaana-Maija Koivistolta.

Väitöskirjaa ohjaavat:
Jari Multisilta, tekniikan tohtori, johtaja, Helsingin yliopisto, CICERO Learning verkosto
Hannele Niemi, FT, kasvatustieteen professori, Helsingin yliopisto, Käyttäytymistieteiden laitos
Elina Eriksson, THT, dosentti, johtaja, Metropolia ammattikorkeakoulu, terveys- ja hoitoala

Appendix 3. Informed consent form

TUTKIMUS- JA TIEDOTUSLUPA

Virtuaalipotilaan kehittäminen ja testaaminen

Tutkimuslupa:

Annan luvan kuvattujen videotallenteiden käyttämiseen tutkimustarkoituksessa	kyllä □	ei □
Tietokonesovellukset saavat tallentaa toimintaani	kyllä □	ei □
Ymmärrän, että osallistumiseni tutkimukseen on vapaaehtoista, ja että voin keskeyttää osallistumiseni milloin tahansa	kyllä □	ei □

Tiedotuslupa:

Tutkimushankkeessa kuvattuja videoita saa esittää

tieteellisissä konferensseissa	kyllä □	ei □
hankkeen internetsivuilla	kyllä □	ei □
koulutus- ja opetustarkoituksessa	kyllä □	ei □

Tutkimushankkeessa otettuja (videomateriaalista taltioituja) valokuvia saa esittää

tieteellisissä julkaisuissa	kyllä □	ei □
hankkeesta kertovissa esitteissä ja lehtijutuissa	kyllä □	ei □
hankkeen internetsivuilla	kyllä □	ei □
koulutus- ja opetustarkoituksessa	kyllä □	ei □

Paikka ja aika

______________________________ ________/________ 2013

Allekirjoitus

Nimenselvennös

Appendix 4. Information sheet 2014

TIEDOTE JA TUTKIMUSLUPA TUTKIMUKSEEN OSALLISTUMISESTA

Hyvä tutkimukseen osallistuva!
Teitä pyydetään osallistumaan tutkimukseen, jossa on tarkoitus kehittää virtuaalista oppimisympäristöä hoitotyön opiskelijoiden kliinisten arviointi- ja päätöksentekotaitojen oppimisen tueksi. Simulaatio-oppimispeliä on kehitetty osana Metropolia ammattikorkeakoulun Terveys- ja hoitoalan yksikön Teho Pro -hanketta (2011-2013) ja sitä on kehitetty yhteistyössä Metropolia ammattikorkeakoulun ja ohjelmistoyrityksen kanssa. Kehittämistä jatketaan vuosina 2014 ja 2015 Metropolia ammattikorkeakoulussa monialaisessa työryhmässä. Simulaatio-oppimispelin kehittämisestä ja tutkimisesta vastaa TtM, lehtori Jaana-Maija Koivisto, Metropolia ammattikorkeakoulu.
Simulaatio-oppimispeliä kehitetään opettajien ja opiskelijoiden palautteen perusteella design-tutkimuksen mukaisesti sykleissä, joissa suunnittelu, testaaminen, analyysi ja uudelleen suunnittelu vuorottelevat. Kehittämiseen liittyy myös Jaana-Maija Koiviston väitöskirjatyö, joka hyödyntää testaustilanteissa kerättyä aineistoa. Tutkimukseen on saatu lupa Ammattikorkeakoulun terveys ja hoitaminen -yksikön johtajalta.
Simulaatio-oppimispeliä testataan hoitotyön koulutusohjelman opettajilla ja opiskelijoilla. Tutkimuksessa ollaan kiinnostuneita siitä, miten pelin potilasskenaariot ja teknologiaympäristö tukevat opiskelijoiden oppimista. Testaustilanteessa tutkimukseen osallistujan pelisessio videoidaan. Lisäksi opiskelijoiden kokemuksista kerätään tietoa kyselylomakkeella.
Testaustilanne kestää noin kolme tuntia. Testauksen järjestää Metropolia ammattikorkeakoulun lehtori Jaana-Maija Koivisto. Osallistumisesi tutkimukseen on vapaaehtoista ja sinulla on mahdollisuus keskeyttää osallistuminen tutkimukseen heti niin halutessasi. Hankittu aineisto suojataan ja säilytetään sekä sitä käsitellään luottamuksellisesti. Aineisto säilytetään 10 vuotta tutkijan työpaikalla Metropolia ammattikorkeakoulussa ja tutkijan kotona. Aineistoa pääsee käsittelemään tutkija ja väitöskirjan ohjaajat.

Lisätietoa tutkimuksesta voitte kysyä lehtori, terveystieteiden maisteri Jaana-Maija Koivistolta
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Elina Eriksson, THT, dosentti, johtaja, Metropolia ammattikorkeakoulu, elina.eriksson@metropolia.fi

Paikka ja aika
____________________________________/________ 2014

Allekirjoitus

Nimenselvennös